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PERSONAL RELATIONS OF TEACHERS WITH NATIONAL ENGINEERING SOCIETIES*

By CALVIN W. RICE, Secretary,
The American Society of Mechanical Engineers

The object of all education is to develop citizens—citizens who are to be lofty-minded, unselfish and devoted to the welfare of the community. Technical training is secondary.

After the masterful addresses of yesterday and the important discussions last evening and this morning, I feel very humble. I join General Mitchell in the statement that he should be the last speaker of the morning because I think his point, namely, the relation of the teacher to the community is the most important of all.

President Hoover recently in greeting the Boy Scouts said we must add to the three R's one more R—Responsibility to the community.

Last month on the occasion of the dedication of the new home of the New York County Lawyers Association, Chief Justice Hughes said that "*expert public service* had given a peculiar dignity to the profession of the law." William Nelson Cromwell, on this occasion, contributed $150,000 to establish the Law Foundation. Of the nine objects of this Foundation, four (abbreviated) are:

First, Elevation of the Standards of Admission to the Bar and the Practice of the Profession.

Second, Cultivation of the Highest Standards of Professional Ethics.

Third, Encouragement of Coöperative Fellowship for the Good of the Profession.

Fourth, The Promotion of Justice as the Bulwark of National Life.

Dr. Millikan and others have made similar statements.

Dean Anthony was quoted by President Rees as having stressed that it is the manner of teaching. Professor Barker spoke of the importance of producing "men." If Dean Anthony were here, no doubt he would state that of the 6,700 cards returned in answer to a questionnaire sent to leaders of industry 85 per cent. placed Character as the most essential quality. In the votes this year among certain college students, it is interesting to note in the

* Presented at the annual meeting of the Society for the Promotion of Engineering Education, Montreal, Friday, June 27, 1930.

answers to various questions, facetious as well as serious, that there again the student named Character as the most desirable quality.

Professor Kinsloe spoke of the unit system at Harvard, Yale and other institutions and it is obvious that the leader in those unit houses must be a man of character.

In order, therefore, to maintain the quality of the members of the Engineering profession and of the Engineering societies, the most intimate coöperation on the part of the members of the teaching profession is solicited and we must commence at the very foundation. And I therefore propose that in the selection of all qualified candidates for teachers of any subject you select men of character and of sympathy. To illustrate what I mean, Dean Bishop told of an incident of the visit from Dr. Mayo of Rochester who was the Commencement speaker. When Dr. Mayo went to his room in the hotel, he found the corridor filled with persons seeking to consult him. When he went to his car to go to the University, one person succeeded in reaching him and although about to go to the Commencement address he nevertheless, because of his great feeling for humanity, asked the person to step into the car and to undress, Dr. Mayo there diagnosed the patient's malady and prescribed.

To go now to the specific relationships of members of the teaching profession, to the professional engineering societies, I will state eight points that to me are important:

1. In the United States we have the concept that each person is to develop himself to the utmost and at the same time develop the greatest capacity for coöperation.

In every suggestion I make, coöperation is involved.

An individual can contribute more to his profession through an organization than separately and outside of an organization. Therefore, every teacher should be a member of the S. P. E. E., and as soon as possible he should join the Engineering Society which best represents his specialty.

It is entirely appropriate to bring out incidentally that by common consent the approved means by which a professional man may bring his attainments to public notice is through participation in the activities of the organization of his profession. In this connection, I am very happy to give testimony to the contribution which has already been made by the members of the teaching profession to the work of the engineering societies. In the four national engineering societies, the statistics show that on the average 16 per cent. of the presidents have been members of the teaching profession. In committee work one finds that 7½ per cent. of the committee men are teachers.

As a collateral advantage, the mutual benefits are important in the contacts that are made. If any one should ask a graduate after he had been out of college a few years what were the benefits he had derived from a college education it is doubtful if the graduate could answer quickly and it is also doubtful if he would say technical equipment. In all probability the reply would be "contacts." Contacts with the teachers and with one's associates. Therefore, these contacts of the teachers with men of affairs of the world, because it is obvious that committee men are the men having the finest minds and the most up to date knowledge, in turn give a teacher a convincing manner and an atmosphere of authority in the classroom. Conversely, the men in actual life work become acquainted with the work of the teaching profession and will develop, we will trust, a sense of obligation to share in the work of preparing men for the profession of engineering.

2. *Research.*—In no one activity have the participation and coöperation of the two groups, the S. P. E. E. and the engineering societies, been more important than in research. Still greater effort can be made along the line of making industry research-minded, emphasizing that if our nation is to maintain its prestige still further research must be continuously undertaken.

As an example of the benefit of research in the particular manner on which I wish to place the most emphasis namely, for the *common welfare,* I wish to point to smoke abatement. In the several colleges, more recently Stevens Institute of Technology, a Chair has been founded on that subject and one of the recognized experts, Colonel Whitlock of Cleveland, who has developed his authoritative position in the United States through activities in a professional society has now been given a chair for a two-year study and undoubtedly will give special attention to the problem in the Metropolitan District of New York. President Davis of Stevens Institute has been serving on the smoke abatement committee of the city upon the nomination of a national society.

Other examples of this type of success can be given, illustrating the benefit to the community by research and coöperation. I will give one more example, namely, that of International coöperation in research. Researches here followed by conferences abroad have been held for several years on the determination of steam tables, a subject of great importance to the power industry. Members of the staffs of two colleges and the Bureau of Standards have coöperated under the direction of a national society and with corresponding committees and individuals abroad. Representatives from these colleges, the Bureau of Standards and the National Society have regularly gone abroad and are now abroad with expenses paid from funds secured by the Committee.

I wish to especially compliment many that are in this room who have made the University with which they are connected of special service to the people of their respective States.

3. *Travel Fellowships and Lecturers.*—Several of the societies have travel fellowships and members of the teaching staff of colleges have been awarded these scholarships and conversely some of the travel scholars of colleges have been assisted by the engineering societies in making contacts abroad. This should be still further encouraged. It brings specific knowledge to the United States for the benefit of our nation as in the case of the Freeman Travel Scholarship, securing information for hydraulic laboratories resulting, as you all know, in an appropriation from the present Congress of $350,000 for the establishment of a hydraulic laboratory under the direction of the Bureau of Standards. It also broadens the view of teachers and in turn enables them to be more authoritative in the classroom and to give out an atmosphere of goodwill and tolerance in our world relations.

The visit of a teacher abroad in either direction is a stimulus not only to the students but to the faculty itself and addresses before colleges and engineering societies can often be arranged.

4. *Attendance at Conventions.*—I wish to emphasize to the colleges the desirability of recognizing the importance of appropriations which will provide for official representation with mileage to meetings of certain organizations. This can be systematically arranged so that membership in the leading bodies of the world are apportioned among the faculty. In this connection it should be brought out that the teacher through his familiarity with the work of the society incidentally becomes the natural advocate of the society to the student so that the latter seeks membership as early as possible in life.

5. *Vocational Advisors.*—I recommend developing still further vocational advisors in each of the branches of engineering and that they contain (*a*) representatives of the alumni, and (*b*) representatives of the societies.

6. *Adjustments of the Curricula.*—The teaching profession of its own initiative has taken the lead and at no time has industry or the engineering societies been more alert than the teaching profession to the necessity for readjustment. The research in this respect has been extraordinarily well conducted by this body but in a natural manner the societies may be invited by you to appoint committees to study continually the subject and to make suggestions for your consideration in the spirit that they have an obligation to perform in this respect.

7. *Group Consciousness.*—The teaching profession and the engineering societies have a great responsibility to develop group

consciousness in the engineering profession. There is the tendency in the specialization in the college, continued in after life by the societies, to put over-emphasis on the specialties. There must be a definite process to counteract this attitude. It is essential for the whole concept of professional ideals and ethics. In the legal profession a man graduates in law and he never loses the concept that he is a member of the legal profession, regardless of his specialty. The same is true of the physician. Without in any way even appearing to suggest a change in the specialization either in the colleges or in the engineering societies I do emphasize the need of a greater degree of coöperation and frequent joint meetings and joint activities of the students in the several branches of engineering so that they may develop early in life the idea that they are members of one great profession.

8. *Professional Societies to be Regarded as a Post-Graduate Course.*—Education is continuous throughout life. Coöperation between the teachers and the societies should be so close that students are encouraged to progress naturally from the college to the engineering society and it is a mutual undertaking of both the society and the teacher to make men worthy of membership in the society on the one hand and to furnish the incentive to assist the teacher in his work of obtaining the greatest devotion while the student is in college.

To recapitulate

1. Every person is to develop himself to the utmost as an individual and at the same time to develop the greatest capacity for coöperation.
2. Research. Seek to make all industry research-minded.
3. Develop travel fellowships and interchange of lectures between nations.
4. According to some system encourage colleges to make appropriations for attendance at conventions.
5. Still further develop vocational advisors.
6. Invite the appointment of committees on curriculum.
7. Develop professional group consciousness of the engineering profession.
8. Develop intimate relationship between colleges and engineering societies, emphasizing that education is continuous throughout life.

To carry out the suggestions of the morning, I recommend the appointment of a committee and that all the papers of the session be referred to it. This committee, in turn, to invite the appointment of corresponding committees in each of the societies. The writer pledges the most cordial support and coöperation of the engineering societies.

INTRODUCTION TO THE PRACTICE OF ENGINEERING

By PHILIP S. BIEGLER

Dean, College of Engineering, University of Southern California

There has been a considerable interest of late in freshman courses for engineering students, and, at the risk of making suggestions that are not new to many of the members, I shall explain briefly the orientation course given at the University of Southern California which has been developed over a period of years and which, we believe, now has taken on fairly permanent form.

In former years all new students in the University were required to take a course in Orientation, but the engineering students, with the coöperation of members of the faculty, arranged, through the agency of the professional societies such as the A.I.E.E., for lectures and inspection trips quite apart from the university course in orientation. Upon the organization of the College of Engineering in 1928, one lecture period a week was set aside in the schedule for engineering lectures and student and faculty meetings, and as few classes as possible were scheduled for Friday afernoons also. An excellent program of lectures and trips was arranged for each semester, providing a lecturer for every other week and an afternoon trip for the alternate weeks. A typical program for one semester follows:

Lecture	Commander J. S. Evans, Chief Engineer, Battle Fleet, U. S. N.
Trip	U. S. S. California
Lecture	Mr. R. B. Stringfield, Chief Chemical Engineer, Goodyear Tire & Rubber Company of California
Trip	Goodyear Tire & Rubber Company of California
Lecture	Mr. A. P. Hill, Acoustical Engineer, Electrical Research Products, Inc.
Trip	Electrical Research Products, Inc., or Southern California Telephone Company
Lecture	Mr. T. E. Swigert, Engineer of Production, Shell Oil Company
Trip	Standard Gasoline Company plants
Lecture	Mr. R. J. C. Wood, Electrical Engineer, Southern California Edison Company
Trip	Hydroelectric plants of the Southern California Edison Company in Mill Creek Canyon, and Colton Cement Plant (week-end trip)
Lecture	Mr. G. J. Carroll, Manager, Consolidated Steel Corporation

Trip	Llewellyn plant, Consolidated Steel Corporation
Lecture	Mr. J. H. Kindelberger, Chief Engineer, Douglas Aircraft Corporation
Trip	Douglas Aircraft Corporation
Lecture	Professor D. M. Wilson, "Engineering in Porto Rico"

Such marked success attended this program that it was decided to introduce a definite course, one unit each semester, to be required of all beginning engineering students, and the University voluntarily withdrew the general orientation course as a requirement for engineering students.

The new course was called "Introduction to the Practice of Engineering," and the name indicates its purpose or objective. A very fine group of men responded to invitations to lecture and gave the students a valuable bird's-eye view of many fields of engineering activity. Where possible, inspection trips followed lectures in such a way as to illustrate the talk.

When this program became a credit course, the students were required to hand in reports of from four to five hundred words on the trips, and great care was taken to make it possible for them to get reliable information concerning the industry visited. Usually mimeographed sheets are prepared giving the principal data of interest concerning the plant or field to be visited, and an attempt is made to have a sufficient number of guides so that there will be one guide for every twelve or fifteen students. It has been found that the report requirement adds very substantially to the value of the program, because the students are thus "on their toes" to get all possible information during the inspection trip. The reports are also read and criticised by the instructors who have these students in freshman English.

In an industrial community such as Los Angeles and its suburbs, it is possible to carry out a four-year program of lectures and inspection trips without repetition, and we find that older students in considerable numbers attend both lectures and trips after they have completed the required two semesters.

The College of Engineering is made up of the divisions of Chemical, Civil, Electrical, General, Mechanical, and Petroleum Engineering, and during the course of the year the program contains material of interest to students in all these branches. Moreover, we encourage our speakers to give the students, in addition to the technical material presented in the lectures, something of the philosophy of life for a professional man.

It is our belief that we have developed a very successful orientation program for an urban university in the midst of widely diversified engineering activities.

A LIBERAL EDUCATION

By J. HUGO JOHNSON
Head, Dept. of Electrical Engineering, University of Idaho

Fifty years ago it was only the exceptional high school graduate who went to college. Even twenty-five years ago most parents considered that they had done well, indeed, to afford their children the advantages of a high school education. Now, the youth of the land feel abused if parents do not, in part or whole, help them to attend one of our numerous colleges or universities.

This unparalleled rise in attendance at our institutions of higher learning has caused a corresponding rise in taxes in general and in particular it has imposed a very considerable financial burden on the families to which the students belong. Some say that the time spent in college is but little better than a four year vacation, a respectable way of postponing the inevitable necessity of choosing and working at remunerative employment. And there are not a few among the graduates each June who would seem to have used their own time and their parents' money only to indulge the frivolous whims of an unambitious, undisciplined, and undeveloped mind.

The four years spent in college, however, may have been utilized in a most profitable manner. Some of the more desirable results may be a thoughtful consideration for the rights of others, a tolerant respect for their neighbors convictions, an ability for and an enjoyment in pleasant coöperation with one's fellows, a capacity for self-enjoyment when alone, the development of real convictions as to standards of life, and a habit of seeking a definite solution for all problems through a fearless, honest balancing of carefully ascertained facts.

The parent curriculum of all college courses is that offered by the College of Letters and Science. Originally, the couse of study was rigidly prescribed, including English, the classics, modern languages, natural philosophy and mathematics. Then there came the elective system which held that students should have a choice of studies. With the development of innumerable highly specialized courses, this range of election grew and grew until a student usually chose over half his studies absolutely as he pleased, although he was supposed to receive the cursory approval of a dean or student advisor.

Thus, it comes to pass that the serious-minded, mature student

receives a thoroughly worth while training; the immature and "butterfly" type of student, under the casual guidance of his classmates, chooses a haphazard conglomeration of courses, which may be good in themselves, but which have little or no correlation; while the shirker chooses a maximum of "snap" courses where he need not "crack a book" during the term. It must be admitted, however, that these last usually "go in for outside activities" with a vengeance and receive a vastly over-rated training in athletics or a form of social life which may be of value in developing the social graces.

There are but few who will not be more than ready to urge that a liberal education is very desirable. The means will inevitably vary, however, with the times, the institutions, and the student. Most American students are mechanically-minded or what is usually the same thing, of a mathematical turn of mind. For those, then, who find mathematics not too difficult, it would be much worth while to consider the advantages offered by an engineering education in the way of achieving the results usually sought from a course in the College of Letters and Science—entirely aside from the possibilities offered by the technical education as to the gaining of a livelihood later.

A large percentage of all engineering curricula is composed of "stiff" courses. To complete any such course of study a student must learn to work hard, regularly and consistently. Such concentration is a form of character training too often entirely omitted from our children's lives.

All types of engineering represent constructive work. If there be destruction, it is only as a necessary preliminary for needed and immediate construction. This attitude tends to give the young student an optimistic, helpful relation toward his human associates and their problems—as a contrast to the aloof, even cynical, attitude one so often finds associated with advanced training.

Machinery will not lie—neither are the physical laws of nature to be fooled or misled by carelessness, wilful prevarication, or a silvery tongue. Mathematical language and explanations must be clear and, above all, correct. These habits of veracity surely and inevitably leave their mark on character. When an analysis or balancing of facts is required, as is usually the case in the solution of a problem either in mechanics or human relations, it is not the question of proving a prejudice, or supporting a client, but rather one of seeking the correct answer without bias or favor. This is a characteristic that cannot be too much stressed under our present condition of civilization. Further, it should be noted that the technical student cannot be satisfied with an open mind and a lib-

eral heart, but he is required to submit a positive answer supported by logical reasoning.

Obviously, such training, if persisted in, develops a citizen with a well considered positive stand on national, local and individual problems.

It is said that engineering curricula are "narrow" in that no work in foreign languages, art, literature, economics, or psychology is included. However, it should be noted that the usual engineering student is required to study English for a period of a year and a half to three years, that practical economics is included in a considerable number of his courses, while applied psychology seems to be mastered by engineers to the extent that they are fast supplanting the lawyer as the chief administrator of "Big Business." A knowledge of the practical facts involved in any special field of human endeavor can be readily acquired from the myriad books now available—whenever the need arises—provided one possesses the proper traits of industry, clearness of thought, and a self-confidence gained through the successful solution of a large number of difficult problems.

While the general course offered by the College of Letters and Science will continue to be best adapted to the needs of a certain proportion of American students, surely, for those capable of completing it, an engineering course offers many real advantages of a purely educational nature for the student seeking a liberal education—entirely aside from its usefulness as a direct preparation for his life's work.

SOME FACTS ABOUT THE SCHOLASTIC ACHIEVEMENTS OF ENGINEERING STUDENTS *

By H. W. MILLER

Professor of Descriptive Geometry, Mechanism and Drawing

AND J. C. PALMER

Associate Professor of Descriptive Geometry and Drawing, University of Michigan

In the autumn of 1923 the Department of Mechanism and Engineering Drawing reached the decision that it ought to be possible to teach all students more efficiently in the subject of descriptive geometry, which is given to freshmen in their second semester, if the high and low students were segregated into classes by themselves. This plan was put into effect the following semester and has been carried on continuously since. From time to time the Department has studied the results of this experiment, but for the most part these studies have dealt only with various phases of the work in descriptive geometry. After a period of seven years, however, it was decided that a sufficient number of these students had graduated, or otherwise terminated their college careers, to warrant a study of their completed records. In the course of this study so many facts of general interest were brought to light that it is felt they should be presented under the above title, rather than to limit the discussion to items concerning a single course; for, while descriptive geometry is still the only course in which the students are regularly segregated, these findings should compel the interest of any department and any college. Indeed, there would be but little point to presenting these facts and observations were it not for the conviction that they are typical of the facts that might be found from an examination of the records of any college of engineering.

Basis of Segregation.—At the beginning of this experiment no one in the Department had had any experience in segregating students, and none had seen any discussion describing the experiences of others beyond certain explanations of various methods of segregation and the advantages that might result. It was necessary, therefore, to make some arbitrary decision as to the basis of segre-

* A modified version of a lecture delivered before the Engineering Drawing and Descriptive Geometry Session of the Summer School for Engineering Teachers, Carnegie Institute of Technology, June 14, 1930.

gation: whether segregation should be based on special tests, on previous scholastic records, or on the basis of some index of general intelligence and capacity. It was decided finally to classify students on the basis of their total achievements during their first semester in college, rather than on the basis of isolated achievements or on the results of tests. In general the first semester programs include courses in English, chemistry, college algebra, engineering drawing and possibly a foreign language, to the total of about sixteen of the one hundred and forty units required for graduation. The grades received at the end of the semester are in terms of A, B, C, D and E, which have the mathematical values of 4, 3, 2, 1, 0. It was decided to use the mathematical average on all work of the semester as the index for classification. The maximum that any student can have is 4, provided he receives the grades of A on all subjects, and the minimum average is zero, provided all grades are E.

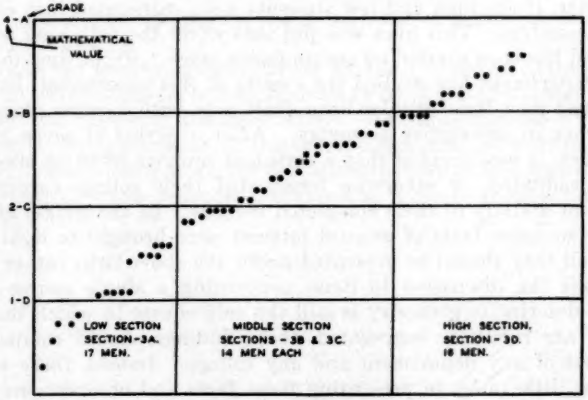

FIG. 1. Division of 61 students of Descriptive Geometry (Drawing 2) into sections, on the basis of scholastic records.

Sectioning.—The average grade of approximately 3 was set as the division between high and average students and approximately 1.5 as the division between average and low students. The experiments have been conducted at all times under average working conditions. Students are enrolled in six different groups according to the hours of the week when they report for work. No attempt has ever been made to influence the group registration of any student. When the list of registrations is received by the Department, it is usually found that there are six groups of from fifty to sixty stu-

dents each, which must be divided, if possible, into sections of not more than fifteen and not less than twelve. For reasons which need not be discussed here, fifteen has been set as an ideal number for a section in descriptive geometry.

Figure 1 shows the arrangement of one of the groups of approximately sixty students as they appeared in February, 1924. When they had been arranged as shown, a section of sixteen was selected from the higher end and one of seventeen from the lower end. It is clear from examination of the diagram that the division point is but arbitrary. The division between the low and average is sharper than that between the average and the high. Two more students might easily have been included in the high section. It is possible even that they should have been included.

The students remaining when the high and low groups had been drawn off were divided into two sections of fourteen each. The lowest of the average men differed very materially in their rating from the highest, and perhaps ideal segregation should take this into account. Actual working conditions do not make this easily possible, however. Since the same practice has prevailed in the segregating of students in the subject of descriptive geometry during the intervening seven years, there is now available the data of seven consecutive years for comparative study.

Qualities of Students.—Immediately after the students had been divided into three classifications, studies were undertaken to learn as much as possible about their capacities and qualities in terms of previous achievements. Whenever the subject of segregation is discussed, one is almost certain to hear mentioned the idea that poor students are inspired to better achievements if permitted to work with the superior ones. There are those who declare that it is not detrimental to the progress of the high students to have the low ones with them in class. A study of the situation as it prevailed when students were taught in heterogeneous groups revealed that there were usually three or four high and three or four low students and twelve to fourteen average ones in a section. It has not been possible to determine, however, to what extent the ordinary administration of heterogeneous groups can or does cater to the capacities and caliber of the superior students while attempting to give every possible opportunity to the inferior ones.

Figure 2 illustrates the achievements of *all* students in *all* subjects during both semesters of the second year of segregation, 1924–25. The facts recorded here are so significant that they are worthy of painstaking study. It is so seldom that one conducts a searching examination of the achievements of students that a revelation of the facts is startling. A discussion of all that is recorded

on these diagrams would be so tedious that only a few will be dealt with. One fact which they disclose is that we are too prone to generalize about the qualities and achievements of students. It is only when they are classified and divided into groups *according* to their achievements that one can learn the facts.

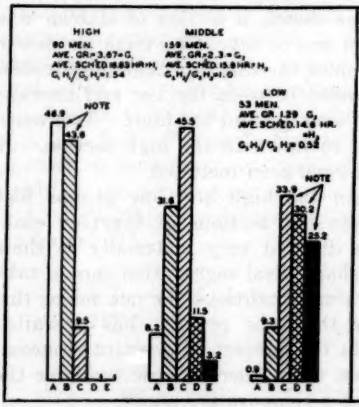

FIG. 2*a*.

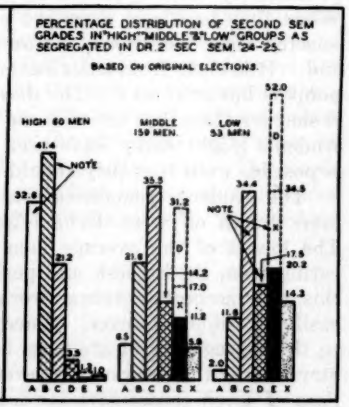
PERCENTAGE DISTRIBUTION OF SECOND SEM GRADES IN "HIGH" "MIDDLE" & "LOW" GROUPS AS SEGREGATED IN DR. 2 SEC. SEM. '24-'25.
BASED ON ORIGINAL ELECTIONS.
HIGH 80 MEN
MIDDLE 159 MEN.
LOW 53 MEN
NOTE
A B C D E X

FIG. 2*b*.

Figure 2 illustrates the wide differences that exist between our high and low pupils in terms of their accomplishments. The high and the low students in the beginning class of 1924–25 are shown here in terms of their achievements in all subjects. It is still the normal practice in college to attempt to teach students of such widely different qualities in the same sections, and presumably to the best interests of all. In the second semester the high students carried an average of 16.7 units with an average grade of 3.04. The low students carried an average of 13.7 units with an average of 1.78. The very pertinent questions arise as to how men of the apparent caliber of the high student can possibly work with the others without permanent injury to themselves and whether the second group can possibly be benefitted by what might be termed inspiration from contact with their superior fellows. Do not the low men suffer from the association, develop inferiority complexes, become quickly discouraged and serve as a handicap to both the class and the instructor?

Another significant fact which appears on Figure 2*b* is an X or withdrawal column. ***This withdrawal column is most striking with the low students.*** There is a date in the semester after which students are not permitted to withdraw from a subject except with a

grade of E. Few freshmen avail themselves of this privilege during the first semester. They have not been used to the privilege of withdrawing from work when it becomes too difficult. They learn from their older friends that if they are to save themselves from being dropped at the end of the second semester, they had better get out of those subjects in which they seem to be failing. The X column should really be added to the E column and on this basis it is seen that such students have an E column of thirty-four per cent in the second semester as compared with twenty-five per cent in the first. The natural question is why do we permit withdrawals at any time except with the grade of E if that be the student's probable fate? In addition, work of grade D can hardly be termed satisfactory and might better be classed with the grades of E. The low students then have a failure column of fifty-two per cent. The combined D, E, X column does not detract from the record of the high students.

The Completed Study.—Although the Department has continued to investigate the progress of the students who entered college in the three years, 1923, '24 and '25, it was not possible to complete the study until the past summer. Some students are in and out of college for six years or more. Some require a total of five years to complete the four-year curriculum. It was not possible, therefore, to complete the investigation of the entire college performance of these students before the end of this past school year.

The data charted in Figures 3 to 9, inclusive, represent the cases of all of the high and low students during the three years, 1923–'24, '24–'25, '25–'26, together with the middle group for 1923–'24 only.

Some of the questions which it was desired to answer were: (1) What is the degree of correlation between the first semester achievement index employed as the basis for classification and segregation and the achievements of the full four years; that is, what is the relation between the percentage of units of work completed with the grade of A in the first semester and the total percentage of units of grade A completed in the entire curriculum. (2) What happens to our superior students? (3) How many years are required by the average and poor students to finish the four-year requirements? (4) What is the trend of the quality of the work of all students as they proceed through college? (5) What is the effect, if any, on high students of the practice of teaching them in classes with average and low students? (Descriptive geometry is still the only subject in which all students are regularly segregated.)

Figure 3 illustrates the relation that was discovered between the distribution of grades received by the three classes of students on

their first semester work and on the total accomplishments in college. The curves which represent the distribution of letter grades for the fifteen to eighteen units for the first semester are so nearly identical with the curves which represent a similar distribution for the entire four or five years that it seems reasonable to conclude

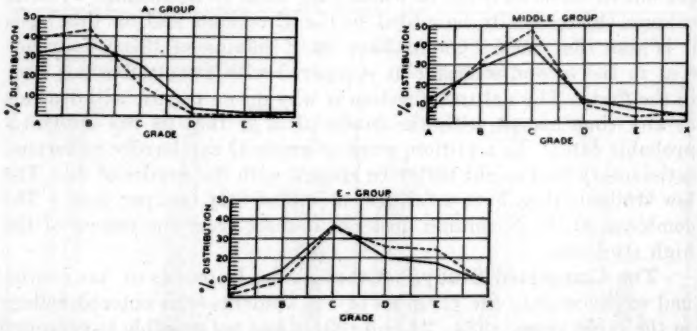

FIG. 3. Comparison of first semester grades and total grades earned by group. (Legend: First Semester Grades – – – –, Total Grades ———.)

that *the first semester index of the students' prospects in college is as nearly perfect as one could wish.* To all intents and purposes the curves are the same. If the curves warrant this conclusion, it is evident then that numerous fond ideas with reference to a student's finding himself in college or doing poor work in certain subjects because they are not to his liking, have little support in fact. Of the one hundred and fifty-nine students classified as "High," one hundred and seventeen graduated. Of the forty-two who withdrew before graduation, only two left the college with a total grade average less than 2.0. Of the one hundred and forty-nine students classified as "Low," nineteen graduated. Of the one hundred and thirty who withdrew before graduation, only two left with a total average as high as 2.0. A certain percentage of high students find that they do not like engineering. They do not learn this fact, however, through poor accomplishments. They seem to do good work out of mere self-respect. They simply come to the conclusion that engineering is not what they thought it is and they do not like what they find it to be. On the other hand, experience with low students fails to support the idea that they might have been more successful had they started in some other part of the university. Their poor achievements seem to be the result of poor preparation, lack of interest, lack of industry and lack of ability. The agreement between the first semester and the four years' achieve-

ment curves is so perfect that the low student might profitably accept the verdict as a prediction of his probable prospects.

Endurance Prospects.—Figures 4, 5 and 6 show some interesting facts with reference to the possibilities of all students in terms of the number of years they might be able to continue in college and the differences which exist between students who finish in four years and others who finish in five.

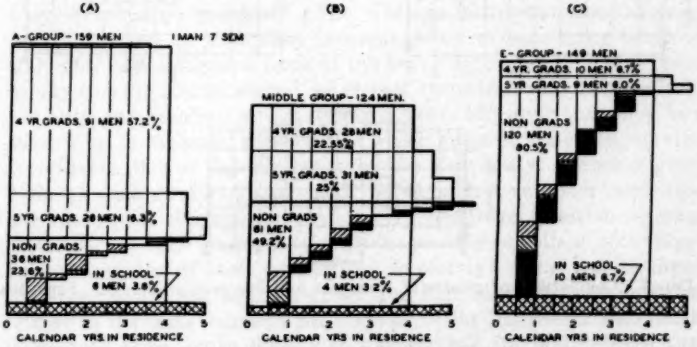
(A)
A-GROUP-159 MEN
1 MAN 7 SEM
4 YR. GRADS. 91 MEN 57.2%
5 YR. GRADS. 28 MEN 18.3%
NON GRADS. 36 MEN 23.6%
IN SCHOOL 6 MEN 3.8%
0 1 2 3 4 5
CALENDAR YRS IN RESIDENCE
(B)
MIDDLE GROUP-124 MEN.
4 YR. GRADS. 28 MEN 22.55%
5 YR. GRADS. 31 MEN 25%
NON GRADS 61 MEN 49.2%
IN SCHOOL 4 MEN 3.2%
0 1 2 3 4 5
CALENDAR YRS IN RESIDENCE
(C)
C-GROUP-149 MEN
4 YR. GRADS. 10 MEN 6.7%
5 YR. GRADS. 9 MEN 6.0%
NON GRADS 120 MEN 80.5%
IN SCHOOL 10 MEN 6.7%
0 1 2 3 4 5
CALENDAR YRS IN RESIDENCE

FIG. 4. Life charts of high, middle and low groups.
(Legend: Requested to withdraw for scholarship ▬▬ Withdrew ///// Withdrew while on probation \\\\\.)

Seventy-three per cent of the high men graduated. A total of twenty-three per cent left college of their own choice, either because they did not like engineering or for economic reasons. Seventy-two per cent of those who graduated did so without any seeming difficulty in the four years. The curve of achievements of the four-year men on Figure 5 is noticeably higher throughout than the curve of the twenty-seven per cent who required five years. This is worthy of attention. It is commonly believed that there is not much difference between the caliber of the men who graduate in four years and those who graduate in five. It is generally thought that economic difficulties are responsible for the five-year students, particularly if they be reasonably good students. Whatever we may like to think the reasons are for the additional year, we find one pertinent fact from a study of achievements, that the five-year men are inferior to the four-year men from the very beginning.

Fortunately for this investigation, the College was particularly lenient in giving the low students the benefit of the doubt as long as there seemed to be any possibility at all of their completing the curriculum. This group started with one hundred and forty-nine men and nineteen of them succeeded in graduating. Figure 4*C* indicates that very few arbitrary actions were taken to drop such

students until the trend of their achievement had descended to the point where it was clearly impossible for them to graduate. A total of one hundred and twenty, or eighty per cent, of the one

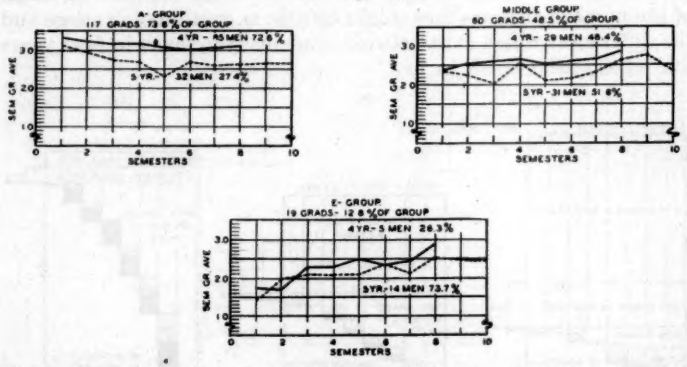

FIG. 5. Comparison of grades of four-year and five-year graduates. Semester grade averages.

hundred and forty-nine men, were "continued on probation" and usually with reduced schedules of hours until the last of them was disposed of at the end of the first semester of the fourth year. Of

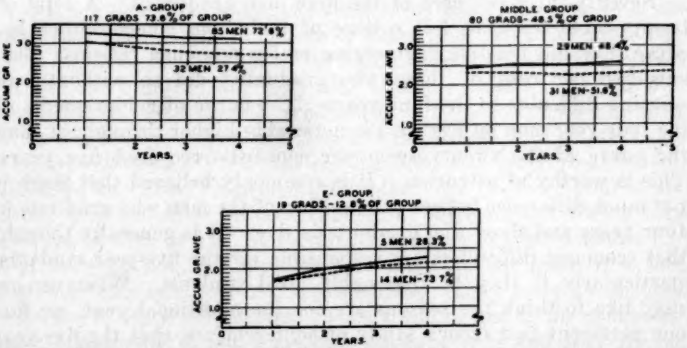

FIG. 6. Comparison of grades of four-year and five-year graduates, Accumulated grade averages.

these one hundred and twenty students, seventy-nine were finally requested to withdraw on account of poor scholarship and another fourteen voluntarily withdrew while on probation. Although these students were in school for periods of from two to seven semesters,

it is very doubtful if they actually were benefitted by their stay. Collectively these ninety-three students spent three hundred and thirty-seven semesters in college. The College officially branded as unsatisfactory (Probation and Home List) two hundred and sixty-nine semesters, or eighty per cent, of this work. Can we believe that the doubtful benefits derived by such work offsets the serious delay in getting these students started upon whatever other careers they eventually pursued? The College estimates the average yearly expense of a student in engineering at something between $800 and $900. Upon a basis of the lower figure, we find that these ninety-three students wasted, or at best spent in a very futile effort, not only one hundred and sixty-eight years of young manhood but something in excess of $134,000, to which must be added an equally formidable item of expense borne by the University. Since Figure 3 shows such excellent agreement between first semester performance and total accomplishments, a very pertinent question is, *why do we permit such students to continue so long in college after they have demonstrated their possibilities so clearly?* Is it fair to these students themselves, to the average and high students who must be taught in the same classes with them or to the instructor who must labor with them, or to those who pay the bill for maintaining the university? Is it not probable that these men develop such a sense of inferiority before they leave college that the idea is fixed in them for life? Could any greater injustice have been done them had they been dropped at the end of the first semester or at the latest at the end of the second semester on the basis of their records? Finally, what chances have the nineteen men who finally graduated for success in the profession of engineering, since but a brief investigation reveals that the engineering work of the country is being done by less than one half our graduates. Is it not true that the competition for success in engineering is actually between individuals of the superior group and that the average and lower men must certainly do something else?

Figure 7 serves to illustrate the quantitative as well as qualitative differences between the accomplishments of the graduates who were classified in their second semester as high, average or low students. Those in the high group received grades of A on a total of thirty-three per cent of their college work. They required one hundred and forty units for graduation and they had more than the required total stamped with grades of A, B and C. The average students had but thirteen per cent of A as compared to thirty-three per cent by the superior students and had only one hundred and thirty units of quality A, B and C. They had to use ten of the quality of D, a sort of compromise grade. The low students com-

pleted but fourteen units with the grade of A. They found it necessary to use not only their A, B and C work, but practically every unit of work of the grade of D that they possessed to graduate. The interesting fact is evident, too, that they average a total of

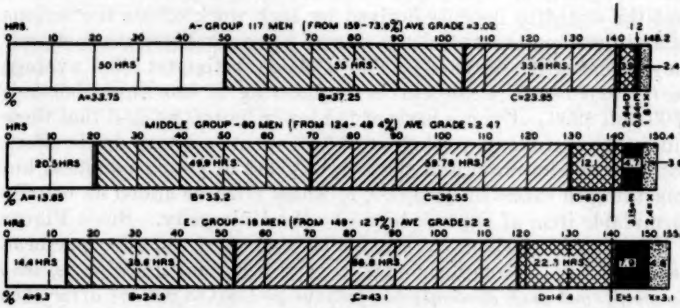

FIG. 7. Comparison of quantity and quality of work done for graduation.

one hundred and fifty-five units of work taken in order that they might pass one hundred and forty units, even including the fourteen per cent of grades of D.

The Slump of the Superior Students.—Figures 8 and 9 are termed Performance Charts. They are perhaps the most interesting and certainly the most important of all. It was shown on Figure 3 that the correlation between the first semester and the four-year achievements of all qualities of students is nearly perfect. Students do demonstrate their capacities and possibilities in their first semester in college. Superior students demonstrate that they are superior and inferior students demonstrate that they are inferior. The question arises, then, at the end of a superior student's first semester as to whether he should not continue throughout college to be just as superior as he has just shown himself to be. And if not, why not? Is it not true that our finest athletes attain their greatest success by virtue of training suited to their particular abilities and to competition? Figures 8 and 9 illustrate the facts for superior average and low students. The G. H. (Grade $\times$ Hours) or quality-quantity index of achievement is employed in determining the curves. This G. H. rating ought surely to be a capacity index, but one is almost forced to believe that with the high students it is but a performance index.

Figure 8*a* shows that from the end of the very first semester the achievement curve of high students slopes *downward*, while the achievement curves of the average and low men rise. Why? Figure 8*b* is for graduating students only and is worked out on the

basis of years instead of semesters, thereby approximately doubling the ordinates. The trends are the same as on Figure 8*a*. Another curve is given on this diagram which may furnish the clue to the reason for the downward slope of the curve of the high men. It is the curve of achievements of all graduating students, high, average and low. As one would expect, it is below the curve of A, or high students, and above the curves for the middle or average and E, or low students. Is it not probable also that this fourth

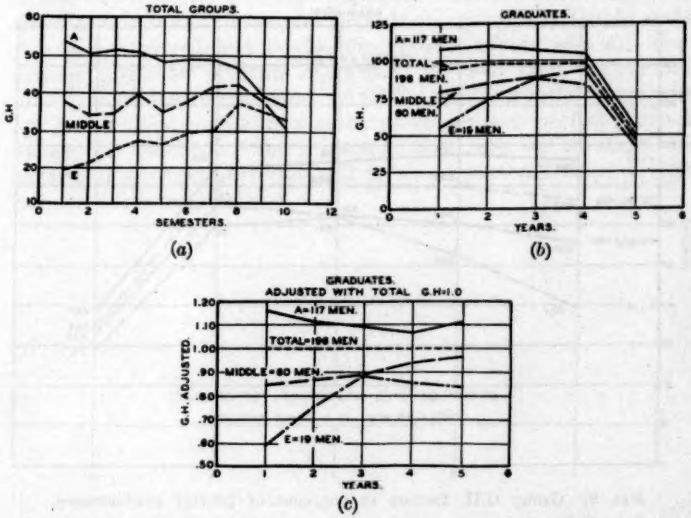

FIG. 8. Comparison of G.H. factors for high, middle and low groups.

curve indicates not only the average achievements but something of the mental plane of instruction throughout college? Perhaps it is even optimistic in that respect. In most athletic competitions we conduct elimination tryouts or tests. As a consequence, the men who compete in the final 100 yard race are all approximately ten second men. High students are just as human as the low although apparently they are not supposed to be. They need to be paced, praised, corrected and trained. They need experienced, talented, sincere, hard working teachers. No others will succeed in developing the best that is in our finest students.

Figures 8*c* and 9 comprise two sets of comparison curves. First, in 8*c*, the average achievement curve of 8*b* is regarded as unity throughout and the other three curves are adjusted accordingly. This may not be the proper way to appraise the achieve-

ments of the high men, however. On Figure 9 the ideal achievement, that is, one-fourth of the total curriculum (thirty-five hours) carried each year, and all subjects completed with a grade of A (4), is set up as the perfect performance (100%). The values on the curves in this diagram for the fifth year are not comparable with those for the first four years. In each group the men who graduate in the fifth year are able to do so with less than an extra full year of work at normal schedule. This reduction in the num-

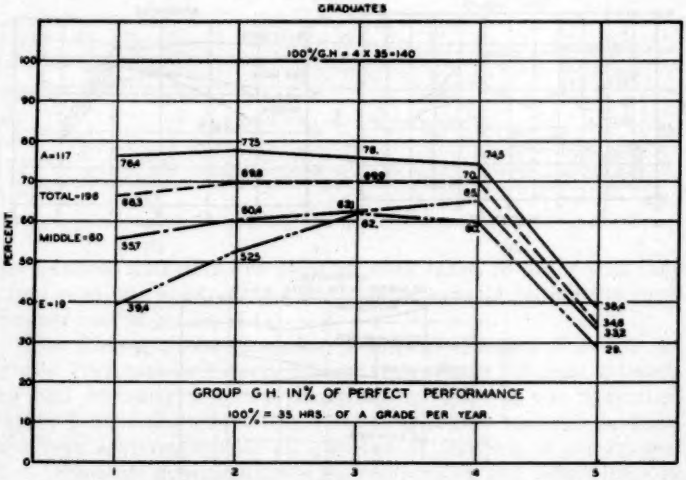

FIG. 9. Group G.H. factors in per cent of perfect performance.

ber of hours carried in the fifth year accounts for the lower values of G.H. Figure 9 shows that the average capacity, or performance, of all of the students remains constant at about seventy per cent. throughout the last three years. The significant fact is that the low and middle students show a marked improvement while the high students show a steady decline during this period.

In Conclusion.—Aside from the seemingly evident fact that our high and low students can be quite accurately selected during their first year in college, no attempt is made to draw further conclusions. The following pertinent questions may well be raised, however. Would the conditions noted in Diagram 9 be the same if the high and low students were taught in segregated classes throughout their course? Is the improvement shown by the low students due in some part to inspiration received from the high students? Is the decline of the high students accounted for in some part by a

growing sense of superiority and self-satisfaction due to constant self-comparison with fellow students whose average capacity is below their own? Would the high students be inspired to maintain and improve their demonstrated abilities if taught in segregated groups where their work would be compared with that of their mental equals? Is some of the time and effort required of the instructor, and of the class as a whole, to pull nineteen poor students up to a graduation standard being made at the expense of one hundred and seventeen superior students? Are we justified in retaining in our classes, for periods up to seven and eight semesters, one hundred and thirty low grade students who can never graduate, if their presence detracts in the least from the performance of the superior students? Are all conditions satisfactory when our best students maintain a seventy-five per cent perfect performance? In conclusion and in summation: are we so much concerned in salvaging inferior and mediocre material as in developing our finest material?

CAN THE TEACHER JUSTIFY HIS JOB?*

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To most classroom teachers it would doubtless seem unthinkable, if so preposterous an idea should ever occur to them, that education might go on quite as effectively as at present even if classroom teachers were to be universally abolished. Teachers in general are apparently accustomed to take it for granted that they, as teachers, are indispensable to any orderly and effective scheme of formal education. They would doubtless base their claim to indispensableness upon the two-fold responsibility which is theirs: the responsibility, on the one hand, for stimulating and inspiring the students entrusted to them, and the further responsibility, on the other hand, for adapting the various phases of the teaching process to their students' special abilities and needs. In the duties which teachers supposedly perform in connection with each of these vital responsibilities, no agency except the classroom teacher (so most teachers would seem to assume) can ever render thoroughly effective service.

So widespread is this assumption that any serious questioning of the classroom teacher's importance is likely to be rare. Yet such questioning does occasionally take place. It has most recently taken place as a result of certain investigations which have been concerned with the direct results of the classroom teacher's work. In so far as these investigations have brought forth even tentative conclusions, they have almost uniformly given room for serious doubt as to the average teacher's real contribution to his students' learning.

The investigations which have furnished most immediate occasion for this doubt have had to do with the effectiveness of so-called individual-instruction materials. Numerous educational experimenters have developed plans for teaching, of which the Dalton and Winnetka Plans are perhaps at present the most widely known, which largely or entirely displace the classroom teacher in many phases of the teaching process. Instead of teacher-conducted "recitations", these plans provide for individual work on the part of the students. The work is based on printed or mimeographed assignment or "job"-sheets, which contain references to

* Summary of a discussion presented at the Civil Engineering Session of the Summer School for Engineering Teachers, Yale University, July 3, 1930.

appropriate reading and practice material, directions for laboratory exercises or for the solution of special problems, and examinations for the rating of the students' achievement. The most completely developed materials of this kind make it possible for the students to proceed with only occasional recourse to the teacher, who finds himself relegated to the background to take charge of the somewhat minor duties of seeing that students make proper use of their materials, supervising the administration and marking of examinations, and keeping records of each student's accomplishment.

These new methods have been introduced with apparently promising results not merely in elementary schools and high schools but in colleges as well. They have been tried with a great variety both of different subjects and of different types of students. Though their effectiveness has not always been carefully tested, particularly when they have been introduced on the college level, the tests which have been made seem in general to permit of a uniform interpretation: that students learn at least as much through this scheme of individual study without a teacher, as through the usual plan of classroom procedure directly guided by a teacher.

In the light of the results from such tests as these, the classroom teacher would seem to find himself hard pressed to defend his supposed indispensableness. Does the teacher actually stimulate and inspire his students? Perhaps; but if stimulation and inspiration are to be measured by their effect on students' learning, then as between carefully worked out printed materials and the average teacher, printed materials can evidently accomplish as much. Does the teacher adapt his instruction to his students' individual abilities and needs? Again perhaps; but if what the students learn may serve here also as a measure, printed materials once more can accomplish as much. The teacher cannot fairly claim to be indispensable unless he can demonstrate his ability either to perform some duty which no other agency can perform, or at least to perform some duty better than it can otherwise be performed. And so far as his duties as stimulator and inspirer are concerned, or his further duties as manager of learning procedure, such investigations as these suggest that the average teacher can lay slight claim to the dignity of being considered indispensable.

Certain other investigations raise no less serious questions as to the teacher's importance, though from a different point of view. If the classroom teacher does succeed in stimulating and inspiring his students and in adapting his instruction to their individual needs it is reasonable to suppose that his teaching will be more effective when he has to deal with small groups of students than when he is confronted with large. Extensive studies have been made of the effectiveness of teaching in large classes as compared with small.

One of the most recent of these studies, and one of the most comprehensive and carefully planned, was carried out in the University of Minnesota.* Its tentative conclusions agree with those to which nearly all previous objective studies of this sort have led: that largely irrespective of what is being taught or who is being taught or who is doing the teaching, students in large classes learn at least as much, on the whole, as do students in small classes. There is here no evidence, of course, that the classroom teacher can profitably be dispossessed of his job. But there is also no evidence that the classroom teacher fulfills his responsibilities on any other than a chiefly routine and automatic basis; so that those prophets of a new day who foresee some mechanical device—a talking motion picture, for example—displacing the teacher of the present order, can find in these investigations, as well as in those previously described, much with which to buttress their prophecies.

There will be many who will object to the conclusions to which both these types of investigations seem to lead. They will maintain, perhaps, that the teacher's most important contribution is unmeasurable—an intangible something which does not lend itself to analysis by objective means, but which nevertheless influences the student directly and valuably. They will emphasize the limited numbers of teachers and schools taking part in both types of investigations, and will insist that whatever may be true of other teachers and other schools, their own scheme of teaching is superior to any which might be substituted for it. They will object that the teacher does contribute something to learning, however poor his teaching may be, else his students would never learn. In all these objections they will seek for some ground on which to defend not only themselves but all of us who are classroom teachers, from the charge that our work might go on quite as well without us.

To those who object that the teacher's contribution is intangible there can be no final answer. Intangibles, by definition, cannot now be measured and can never be measured. They cannot, indeed, even be reasonably disputed; so that the views of a person who holds that the classroom teacher makes an intangible contribution superior to the contribution offered by printed study-materials or by talking motion pictures can no more be disproved than can the views of one who holds the very opposite. Proof, and evidences leading to proof, can only be concerned with tangibles; and in so far as tangible evidence can at present be drawn upon as a gauge of the teacher's success, it does not seem to support the view that the teacher is indispensable.

Those who believe that they themselves, and their schools, repre-

* Hudelson, Earl: *Class Size at the College Level*, University of Minnesota Press, 1928.

sent exceptions to any present conclusions can likewise be given no final answer. It can only be pointed out that the schools and the teachers thus far subjected to these investigations represent a considerable number of educational institutions of various types, and that these institutions were apparently doing teaching of at least average effectiveness under the usual scheme of classroom procedure. In the light of present evidence the burden of proof is on the teacher who believes himself an exception. Does he inspire and stimulate his students more effectively than most other teachers, the country over? Does he adapt his teaching more skillfully to his students' needs? He must show that he is truly superior to teachers in general in these respects, before he can claim greater immunity from suspicion than the results of the investigations thus far conducted would seem to warrant.

The most widespread objections are likely to be voiced, however, neither by those who believe in the intangibility of the teacher's contribution nor by those who consider themselves exceptions to the general rule, but by those who maintain that the teacher's contribution is too obvious to need proof. The teacher does teach and the students do learn: is not the latter fact sufficient proof of the former? It is, indeed; but as an argument for the indispensableness of the teacher it falls, unhappily, very largely beside the point. The investigations do not show that the teacher does not teach: they suggest simply that other agencies can teach as well as he. And suggesting this, they give room for a very plausible doubt as to whether the classroom teacher is actually the significant factor in teaching that he has long been assumed to be.

Hence there is little exaggeration in saying that the classroom teacher, even though he may not be aware of his predicament, is face to face with a serious problem: can he actually justify his job? If the results of these investigations mean what they seem to mean, the teacher cannot fairly assume that his position in the classroom is permanently assured. Talking motion pictures may some day be less expensive than salaried human teachers. Individual-instruction materials are already available for numerous subjects and various types of students, and are less costly than the teachers whom they might displace. Unless the teacher can establish for himself a place in teaching which cannot be filled by these mechanical systems or others of a similar sort, he is likely slowly but surely to find himself one of a vanishing race. Is there a place left for him, or can he be kept from the extinction that may otherwise be his only by public inertia, or by an emotional appeal to his vested rights?

Fortunately for those who are immediately concerned, there is reason to believe that the teacher's present lack of success in prov-

ing himself indispensable can be more or less adequately explained. Any valid explanation of the teacher's relative ineffectiveness is worth considering with some care, since it is likely to indicate a type of procedure which teachers in general will do well to avoid if they are to justify their work, and since it may thus provide a starting-point for determining what types of procedure may in the end prove themselves of undeniable worth. In the present instance, the explanation which suggests itself would seem to have significant bearing on teaching procedure at almost every educational level. It can be most readily illustrated, however, in terms of teaching in the secondary school. Hence there may be profit in considering this explanation with direct reference, for purposes of illustration, to methods of teaching in various secondary-school fields.

The methods of teaching ordinarily followed by secondary-school teachers are surprisingly uniform from school to school. They are so uniform, indeed, that one who spends much of his time in observing school work can predict with extraordinary accuracy the kinds of activities in which the students in any given class will be engaged during the class period. If one visits, for example, a few classes in plane geometry in no matter what secondary schools, one will find in seven or eight classes out of ten almost exactly the same procedure. The geometry teacher will use the first part of the class period by sending to the blackboard as many students as the size of the board will allow, to write out the demonstrations of theorems or originals assigned for that day. Meanwhile he will engage the attention of the rest of the class by calling on them for oral recitations—the solution of review problems, or drill, or perhaps one of the assigned demonstrations being placed on the board. When the students at the board have finished their work the class recitation will abruptly cease, and those who have written out their demonstrations will return singly to the board to present and defend their proofs. The proofs completed, the class-period will be almost over. The teacher will assign further demonstrations, or possibly review, for the following day, with such explanations and comments as time may permit or his conscience may urge. Then the bell will ring and the class will disperse, later to "get" their assignment according to their individual and unaided abilities and inclinations.—Or let one visit a random group of classes in high-school French. A few students copying sentences from the assigned English-into-French on the blackboard, one sentence to each student, while the rest of the class, at their seats, "do" an oral assignment or a drill on vocabulary; an explanation and defense, addressed largely to the teacher, of the sentences written on the board; recitation of the French-into-English exercise for the day; a laborious and joyless translation

from "Le Voyage de M. Perrichon" or "Le Bourgeois Gentilhomme," taken up in the middle, carried through student by student and bit by bit, and broken off a page or two from where it was begun; more exercises, vocabulary, translation to "get" for tomorrow announced as the period closes—this is what the visitor will find in class after class and school after school.—Visit English classes, or science classes, or classes in the social studies or in commerce: the result will be the same. The exact procedure which is followed will differ in detail from one subject to another as the subject matter itself differs, but within any single subject the methods of teaching will be notably regular and uniform.

The methods of teaching are surprisingly simple in outline, moreover, as becomes apparent when one attempts to analyze them. Whether in mathematics or foreign language or history or science or English, the teacher's procedure ordinarily consist of three major parts: setting tasks which the students are expected to perform outside of regular class meetings; providing, either through textbooks or through oral explanations, the materials to be used in performing these tasks; and examining and "marking" the results of the students' attempts to perform them. With so simple an outline of procedure as this, it is hardly surprising that methods in any single subject are almost identical everywhere.

Yet the significant thing about customary high-school procedure is neither its uniformity nor its simplicity. Much more important is the kind of learning which these characteristics of the teaching process demand of the student. He learns, for the most part, not in class, but outside of it, since the classroom time is given up almost entirely to the teacher's examination of the results of his learning. He learns individually, moreover, "getting" by himself outside of class (if he is honest according to the school's arbitrary definition of honesty) the assignment which the teacher has set for him. And he learns largely from books, supplementing the information or directions which the assigned texts contain with whatever recollection he may have of the further information or directions given him by the teacher. It is with learning of this sort on the part of the student that schemes of teaching which would displace the classroom teacher have to compete.

Relying on such teaching methods as these, can the secondary-school teacher fairly expect to show himself indispensable? He assigns, he explains, he tests. Individual-study materials likewise assign and explain and test. Learning directed by the teacher is almost the exact counterpart of learning directed by assignment-sheets; and though students may be expected to learn from the teacher as well as from assignment-sheets, the teacher can hardly be said to teach except as assignment-sheets teach.

Thus there would seem to be a reasonable basis afforded merely by an examination of the teaching procedure which most high-school teachers are content to use, for explaining the relative ineffectiveness of the high-school teacher's work. So far as secondary-school teaching is concerned, the classroom teacher fails to accomplish more than can be accomplished by purely mechanical teaching devices for the simple reason, apparently, that he uses methods of teaching which are in themselves almost entirely mechanical. He meets automatic teaching schemes on no other ground than the one which such schemes can themselves easily occupy—that of routine instruction of individual students, largely through formal textbook materials; and meeting these schemes merely on their own ground, it is hardly to be wondered at that he does not shine brightly by contrast.

The present discussion is immediately concerned, however, not with teaching procedures in secondary schools, but with teaching on the college level, in schools of engineering particularly. The uniformity and undesirable simplicity which seem to characterize most high-school teaching may not be equally characteristic of engineering education. It will be pertinent in any case, before drawing broadly general conclusions from secondary education alone, to consider what the facts may be with respect to teaching procedures in schools of engineering.

To describe college classes in general—and what is true of most college classes is doubtless true of engineering classes—is more difficult than to describe high-school classes in general. The difficulty does not rest, presumably, in the greater complexity and variety of procedure in individual college classes. It springs rather from the obstacles which the principle of academic freedom sets in the way of observation of college teaching. Few persons have had enough glimpses of college work in general to permit them to draw far-reaching conclusions about it. Hence it seems impossible, in the present instance, to offer the kind of description of college classes which is possible in connection with classes in secondary schools. But in place of such a description certain questions may perhaps be raised—questions which bear directly on the matters under discussion, and which may suggest, even though they cannot support, significant conclusions with respect to college teaching.

Does not the usual college teacher—and this includes the teacher of engineering—spend a major part of each class period merely in delivering prepared information to his students? Or, if he welcomes discussion in his classes, does not the "discussion" consist largely in the teacher's supplying the answers to questions which his students raise? When the teacher himself raises questions in his classes, are the questions not in effect largely rhetorical ques-

tions, which he expects—and his students expect it of him—to answer himself in detail, after a brief time has been given to feints at them by the students? If the teacher's method involves requiring daily recitations from his students, do not these recitations consist merely in his examination, point by point, of the results of students' outside study? If the teacher conducts laboratory periods, do not these periods afford simply a well-systematized opportunity for students to do what they have been given directions for doing? Does the college teacher, in other words, do more than set tasks for his students, provide them with information, and examine them as to the results of their outside study? Does he, any more than the high-school teacher, ordinarily offer his students a type of teaching which could not quite as effectively be reduced to print or supplied through talking motion pictures?

Such questions as these are obviously unanswerable for college teachers in general, because of the impossibility of supporting any general answers by reference to demonstrable facts. One can at best offer only a surmise as to what the answers may be. On the strength of such a surmise it will be not unreasonable to hold that there are numerous college teachers whose teaching—like the teaching of many secondary-school teachers—will stand well the scrutiny which these questions provide. Nor will it, perhaps be unreasonable to believe that there are many other college teachers who can show in their teaching few procedures which offer an advantage over purely mechanical teaching devices. So far as the results of experimental studies throw light on the matter, college teaching and teaching in secondary schools seem to be about equally subject to replacement by mechanical schemes. For want of adequate evidence to the contrary, one is almost forced to the conclusion that the apparent ineffectiveness of college teaching procedure is to be explained on essentially the same basis as the ineffectiveness of most high-school work. The college teacher, like the secondary-school teacher, is faced by the need to justify his job; and he can find adequate means for justifying it only by recognizing the apparent probability that his teaching, like most secondary-school teaching, tends at present to emphasize merely routine instruction of individual students, largely through formal textbook materials.

This, then, would seem to be the status of the classroom teacher in college and secondary school alike: the teacher teaches and his students learn, but the teacher teaches after such a fashion that purely mechanical devices can successfully reproduce both the methods and the results of his teaching. The teacher can prove himself actually indispensable in the teaching process only if he can bring about some change in this status. There is obviously one direction, and one direction only, in which he can make a change

which will be adequately effective. That is in the direction of improvement in his own methods of teaching. Somehow or other he must find for himself a scheme of teaching which contributes unmistakable values to the learning of his students, and which at the same time cannot be reproduced, either in method or in effect, by any purely mechanical "system."

That such a scheme of teaching may be found is by no means inconceivable. No such scheme has as yet, to be sure, had its value objectively proved, since none has been tried long enough, or comprehensively enough, or by enough teachers, to give a measure of its strength. At least one scheme of this sort, however, seems of particular promise. It is one which mechanical devices can hardly imitate because it involves more than a routine setting of tests and imparting of information. It is one which may be looked to for results of undoubted value, since it tends not toward mere rote acquisition of formal knowledge and skills, but toward development of the ability to use essential knowledge and skills under conditions in which their use is important. It is a scheme which demands a broader background, greater adaptability, and more exertion on the part of the teacher than does customary classroom procedure. But it gives the classroom teacher full opportunity to prove himself indispensable; so that it is well worth the attention of any teacher who is seriously concerned to justify his job.

The teacher who would adopt this scheme needs to recognize certain facts which in the long run will have much to do with determining the relative success of his teaching.

In the first place, he needs to recognize the fact that class-teaching involves the teaching of *groups* of students. This would seem to be almost self-evident. That it is by no means self-evident in practice is clearly attested by the teaching procedure which most teachers use. The methods of teaching employed in the average high school, and the methods presumably followed by most college teachers, recognize classes of students as mere collections of individual students many times repeated. The teacher addresses himself to a class in almost exactly the way—except, perhaps that his language is more formal—in which he would address himself to an individual student; he calls upon the class during the class period for tasks which are to be performed separately, even though simultaneously, by each individual in the group; he tests his students' achievement almost entirely in terms of what each one, quite independent of the others, has been able to accomplish. Yet he has before him a group of persons at least potentially interested in the same general problems, able to contribute in varying ways and varying degrees to the mastery of those problems, and possessed of

a "group psychology," so-called, which is likely to be of no small significance in their learning.

In the second place, the teacher needs to recognize the fact that the process of group learning, when it is economically and effectively conducted, involves a procedure more or less distinctively its own. People learn in one fashion when each must learn by himself, but in a somewhat different fashion when they can coöperate in learning. The methods of learning which coöperation makes possible ought properly to form the basis for class teaching, if class teaching is to be regarded as synonymous with group teaching.

And in the third place, the teacher needs to recognize the fact that his own part in teaching is chiefly to be found in the contribution which he can make to group learning. Students can profit, through their association with each other in groups, in ways which are not open to them merely through individual learning. Group learning is, therefore, distinctly worth providing for. But whereas individual learning can be more or less successfully guided through various mechanical "systems," the effective conduct of group learning seems likely to be beyond the scope of any merely mechanical device. Hence it is in the conduct of group learning that the classroom teacher must probably seek his own eventual justification.

Obviously the most important task which confronts the teacher, therefore, is to determine what group learning must involve if it is to be economically and effectively conducted. The teacher's ability to provide the conditions under which such learning may take place, and his skill in guiding it to worthwhile ends when it does take place, are likely to represent the principal measures of his success as a teacher.

Group learning is common enough, fortunately, so that examples of it are not hard to find. One has only to observe a number of people who have come together to achieve a common purpose—provided, of course, that they are not dominated by some dictatorial person who establishes himself as their teacher—and one may find in what they do and how they do it a clue to the process which such learning involves. A single instance of this sort will perhaps serve to indicate what takes place when people learn as a group.

This instance is drawn from the history of a certain New England town, some of whose citizens awoke one day to the disturbing realization that the town had no sewer system. These citizens followed a procedure usual in such cases: they wrote letters to the editor of the local newspaper. From the publication of the letters there resulted enough interest in the matter among the townspeople in general so that a meeting was called to discuss ways and means for getting a sewer system. The meeting was largely

attended by a variously assorted group of people: people who wanted a sewer system and people who thought they did not, or were not sure; people who knew something about the operation and maintenance of sewers, and people who believed that sewers would do away with the supply of food for the very profitable pigs kept at the town farm: people who might be expected to contribute in varying degrees, out of technical knowledge and experience or out of no knowledge at all, to the solution of the problem.

The meeting's first act was to elect as chairman a man who, as it happened, knew little of sewers from any technical point of view. The chairman called for statements from those who had been active in arranging for the meeting. It shortly became evident, from comments and questions on the part of various members of the audience, that serious misconceptions existed as to the nature and functions of a sewer system. Hence a considerable time was devoted to an explanation, by a man who had a little technical knowledge of sewers, of the benefits which a sewer system might be expected to confer on the town. As a result of this explanation some few persons who had previously objected to sewers merely as sewers were won over to the majority point of view, and the meeting centered its attention on three definite questions: What sort of sewer system ought the town to have? How much would such a system cost? How could the town raise the money to provide such a system? There were present at the meeting no persons qualified to give any immediate answers to these questions. The chairman therefore appointed, in accordance with a vote by the meeting, two committees, of which one was to investigate the nature and probable cost of an appropriate sewer system, and the other was to inquire into the financial resources of the town. The committees were instructed to report upon a certain date, and the meeting adjourned.

Whereupon the members went upon their several ways, except for two groups. The committee members, who had received definite instructions, proceeded to carry their instructions into effect. Certain other members, who had received no instructions at all, found themselves impelled by their own interest in the matter to look independently into the questions of sewers and finance. Then upon the appointed day the group as a whole met again.

This second meeting opened with a report from the committee appointed to investigate the nature and cost of sewers. The committee had, it appeared, been uncertain at the outset as to how to go about its task, but had at length consulted a firm of engineers in a neighboring city. From the office of this firm it had obtained an imposing mass of plans and statistics, on the strength of which the committee recommended to the meeting sewers of a certain type to

be built at a tentatively specified cost. This recommendation had hardly been presented before a member of the audience gained recognition from the chairman and announced that he too had been investigating sewer systems and their costs, and that he had secured from a different firm of engineers what seemed to him radically different proposals and estimates. A heated discussion ensued, culminating at length in a vote to refer the question of plans and costs back again to the committee which had reported on it, with instructions for a more careful search for data.

The second committee, called upon for its report, proved to have no report to make. "The committee did not realize that the time was so short," the chairman said, "and they had unfortunately done nothing in the matter until too late to be able to present a report." Action by the meeting was delayed while various members of the audience made incisive remarks upon the committee's lack of performance. Eventually a vote was passed discharging the original committee and providing for the appointment of a new one. Then this second meeting likewise adjourned, to wait till the one new committee and the newly instructed old committee should have time to obtain the information demanded of them.

For those who must know the ending of every story, it may be said that the town did at length get a sewer system—or the beginning of one, at least. But for present purposes the story of the citizens' efforts to find out about sewers and eventually to provide them for the town need not be set forth in further detail. The account of these two meetings will provide ample illustration of the process of group learning as it normally takes place. That the process in this instance was one of group learning is doubtless sufficiently apparent. The people who assembled at each of these meetings were concerned primarily, of course, not with learning for the mere sake of learning, but with getting a certain thing done. They could not accomplish their purpose without finding out a great deal that they did not know, and they proceeded to find out whatever was necessary. Learning resulted for almost everyone concerned. A statement of the process of arriving at this learning represents, for present purposes, the moral of the story, and may well be considered in detail, as most morals drawn from stories are.

It should be noted in the first place that group learning begins with the encountering of some recognized problem. The problem must be "recognized" not so much in the sense that it can be stated in so many words, as in the much more important sense that it actively perplexes, or troubles, or appeals to the interest, of the persons composing the group. It must, furthermore, be a problem which concerns these persons as a group—a problem which only group action on their part can solve, or which group action can

obviously solve more effectively than can purely individual attack upon it—if it is to remain for long the focus of any group learning. Given a problem of this sort, as in the case of people's concern with their lack of sewers, and group learning shortly begins to occur.

With the problem definitely recognized and the group in a mood to deal with it, certain natural "stages" in group learning almost immediately appear. There is likely to come at the beginning a period of uncertainty as to what the problem involves—the period marked in the matter of the sewers by the effort of the group to remove misconceptions and to focus attention upon the question at issue. Group discussion of the problem, for the purpose of defining it as clearly as possible, represents this particular stage. Next usually comes some such further discussion, as that which led to the appointment of committees—an effort not so much to define the problem itself as to discover methods for going about its solution. And finally appears a decision as to immediate things to be done—in the case of the problem of sewers, the assignment to individual members of the group (the two committees) of special responsibilities in furthering the solution of the problem. In these stages—discussion of the problem in an effort to define it, discussion of methods of solving it, assignment to individual members of the group of things to do in connection with its solution—are comprised the skeleton of practically every situation in which group learning moves economically and effectively to its conclusion.

The moral of this particular story does not end, however, with an analysis of what happened in the first of the two meetings. Group learning can seldom be carried to its necessary conclusion wholly within the group which undertakes it. Individual members of the group—sometimes selected persons, sometimes every member of the group—must discover outside the group meetings things which the group as a whole does not know, in order to further the attack of the group on its problem. Almost always, in other words, there must be a shift from group to individual learning after the group has reached the limit of its progress as a group, and then a transition to group learning again when the results of individual learning have made further group procedure advantageous.

In the matter of the sewers the transition from group to individual learning is, of course, marked by the asssignment of certain responsibilities to committees. The work of these committees, together with the voluntary investigations of individual members of the group, represent a process of individual learning. At its conclusion group learning begins once more, with the attention of the group as a whole centered upon the results of this individual learning.

In the second group meeting the stages of procedure are identi-

cal with those in the first. There comes at the beginning an attempt to define the problem more clearly in the light of new information supplied by a committee—an attempt furthered in the long run, though apparently confused for the time being, by the voluntary contributions from individual members of the meeting. The discussion of methods of advancing the solution of the problem is concerned in the present instance with the further duties of the appointed committees. Ultimately there is a definite assignment of additional responsibilities to the appointed members, and group learning again gives way to individual learning. The procedure to which this second meeting contributes its part is one which alternates back and forth between group and individual attack upon the problem, with the group as a whole defining the problem, suggesting methods for its solution, and imposing responsibilities upon individuals, and with individuals fulfilling their responsibilities adequately or inadequately, supplying a basis in any case for further progress by the group.

This is the process of group learning as it is likely to take place when people come together of their own accord to get something done. Between such a process and the procedure which goes on in the average classroom there are obvious differences. The usual classroom procedure insists on no problem which awakens the interest of the group as a whole—insists, in many cases, on no problem at all, except the obvious and irksome problem of satisfying an authoritative teacher. Classroom procedure gives room for scant discussion of what is to be done or how to do it: tasks are ordinarily defined and methods of dealing with them outlined not *by* the class as a whole but *for* it. Classroom procedure recognizes little or no responsibility on the part of individual students to the group: responsibility is directed from each individual to the teacher, who, in the last analysis, is sole arbiter of excellence and dispenser of praise or blame. The usual classroom procedure brings forth, on the whole, almost exclusively individual learning, motivated by authoritative demands, carried out in terms of dictated specifications, and gauged by largely arbitrary standards, as compared with the very different type of learning to which group coöperation normally gives rise.

To conclude that the usual plan of classroom procedure ought to be supplanted in every particular by a scheme of unguided group learning is, however, hardly justified. Classroom procedure offers, to its possible advantage, at least one feature which most voluntary group learning does not possess—the presence of a person already adept both in what is to be learned and in ways of learning. Using his knowledge wisely, such a person may add greatly to the economy and effectiveness of group learning. Had such a person been pres-

ent at the first of the meetings for the discussion of sewers, for example, and especially had he been chairman of the meeting, he might have foreseen the various misconceptions which arose and might have led the group as a whole to a speedier and more exact understanding of the problem which faced them. He might also have helped to insure against loss of time and energy on the part of committee members, by suggesting the need not merely for instructing each committee as to what its duties were, but for advising each committee as to promising methods of performing these duties. He might have aided in the evaluation of the committee report by pointing out, even in advance of the committee's own investigation, the desirability of securing pertinent data from a variety of sources. The assistance of such a person in defining the problem at issue when the group's own efforts are obviously unsuccessful, in discovering fruitful methods of investigation or sources of data of which the group itself is unaware, in evaluating the learning which results from both group and individual effort, may obviously add measurably to the total achievement both of the group as a whole and of its individual members.

Yet though group learning under skillful guidance may be more effective than most group learning which lacks such guidance, group learning even without guidance has certain noteworthy merits. The fact that it starts always with a recognized problem is of especial advantage, not merely because common recognition of the problem makes for unity of purpose in the group as a whole, but because interest in the problem leads to a positive effort to learn. The fact that the group itself must define its own problem and reach some tangible decision as to methods of attack upon it represents a further advantage, since under these conditions the group learns eventually not merely what the solution to the problem may be, but how to arrive at such a solution. And the fact that individual members of the group are responsible to the group itself represents a third advantage, in that approval or disapproval by the group is likely to furnish the strongest possible incentive to achievement. Whether in acquiring mastery of particular knowledge or habits or skills, or in learning how to acquire such mastery, group learning seems to hold values which cannot lightly be disregarded.

May it not be a fair conclusion, then, that the teaching procedure which offers greatest promise of truly justifying the classroom teacher is one which combines the advantages of group learning with the further advantages of group learning under guidance? Procedure of this sort gives due recognition to each of those facts which the teacher must take into account: that his classroom work requires the teaching of groups of students; that group learning

involves a procedure more or less distinctively its own; that the teacher's own part in teaching is chiefly to be found in the contribution which he can make to group learning. Basing his work upon this conception of his responsibilities, the teacher would, it is true, find his task a more difficult one than that which the average teacher takes upon himself. Yet the outcome of such a task, in terms of things learned by students and of students' interest and their ability to go on learning, is not likely to be duplicated on any other basis.

Were this conception of the process of teaching to be put completely into effect, it would involve numerous and radical departures from the usual methods of class-conduct. It would bring about changes, for one thing, in the teacher's relationship to his class. To provide the conditions under which students might want to learn as a group, to order the situation in such manner that each of the steps of learning might be carried out at the proper time and to the proper degree, to supply the necessary materials and sources of information by which individual learning might contribute to group learning—these would be the teacher's duties under such a procedure. Instead of arbitrarily setting tasks, the teacher would find himself faced with the necessity for interesting his students in the discussion of major problems, for guiding their discussion toward clarification of the subordinate problems involved, for suggesting to them methods and materials which would be of value in the solution of these problems. Instead of presenting formal lectures, it would be the teacher's function to supply merely such information as students could not readily or economically find for themselevs or to give information which would interest them in further study of the problems at issue. Instead of examining, as sole arbiter of excellence, the students' efforts to perform assigned tasks, it would be the teacher's duty to guide discussion by the class itself of the results of such outside work as had significance for the group as a whole. The teacher would become, in effect, stimulator, critic, and guide, rather than dictator or dispenser of knowledge; and the teacher's skill would be measured by his success in getting his students to learn for themselves, rather than by his ability merely to "teach" in authoritative terms.

Were this conception of teaching to be completely adopted, it would bring about changes also in the organization of subject matter. It seems to be an inevitable result of the simplicity and uniformity of usual methods of teaching, that subject matter should be presented as if all of it needed to be acquired, item by item, in the same way by any one student as by any other. Thus all students are required to read the same books, and perform the same exercises, and write the same papers, even though other books or exer-

cises or papers would serve quite as well the purpose for which they are designed. Under the changed conception of teaching, there would logically arise a clear distinction between the fundamental habits or knowledge or skills which the teacher sought to develop, and the means by which those fundamental outcomes were to be reached. The approach to each new problem would still be the same for all. But the problem itself would be recognized as the development of a certain ability or understanding, and the methods adopted for its solution—for the mastery of the ability or understanding in question—might differ as the aptitudes and interests of the students themselves proved to differ. Hence subject matter would be organized in terms of a two-fold classification. On the one hand would be questions for group discussion, with which all students alike would be concerned. On the other hand, leading out of these questions, would be subordinate problems or exercises or study, differing on occasion for individual students, and offering means by which each individual might carry on the individual learning to which group learning paved the way. In an organization of subject matter which contributed to group learning and individual learning, each in its place, as contrasted with an organization which interpreted all subject matter as appropriate only for individual learning, would be found one of the most radical changes which the new conception of teaching would bring about.

Were this conception to be completely adopted, it would bring about further changes in the formal ordering of class work. Class meetings of uniform length, scheduled for fixed days in the week and for a fixed total of periods-per-semester, would obviously find slight justification in a plan in which the nature of a problem under discussion should determine the methods of study to be pursued. Laboratory work organized on a similarly arbitrary and inflexible basis would likewise have to give way to a more flexible procedure. Outside study assigned in measured amounts, alike for all students, would form no defensible part of the plan. In contrast with these systematically mechanized arrangements by which administrative "justice" is done to students and teachers alike, class discussions and demonstrations might occupy several class-meetings, with no intervening assignments to individuals; individual laboratory work would presumably follow upon group discussions, instead of paralleling them independently; class-meetings and laboratory periods both would extend over longer or shorter periods of time, depending on the nature of the work which they involved; outside study would be assigned somewhat irregularly, whenever it might be needed for its contribution to class discussion or laboratory work.

The mechanics of learning, that is to say, would be at every step duly subordinated to the demands of the learning itself.

If this conception of teaching were to be completely adopted, our system of education would, in other words, be very different from that which is now in existence.

Yet it is perhaps only too obvious that no one can reasonably look forward to any such fundamental revision as this conception might seem to imply. However desirable it might appear to everyone concerned that the projected scheme of teaching be put into effect, its complete adoption either now or in any near future would be inevitably prevented by at least three overwhelming obstacles: by the nature of people in general, by the limitations of students, and by the life-long experience of teachers. There must be concessions to all three of these obstacles if a workable procedure is to be evolved.

The concession demanded by the nature of people in general applies to the administration of the scheme. People seem to be so constituted that their activities must be systematized in order to be successful. Hence the assignment of fixed hours to classes and laboratory work and outside study cannot be carelessly thrown aside. Deplorable though an arbitrary arrangement of schedules may be from the standpoint of pure educational theory, it is probably a necessary condition of systematic education, and must therefore be taken into due account.

The concession which must be made to the limitations of students is less permanent, perhaps, than that concerned with the scheduling of classes, yet it strikes even more directly at the root of the scheme. Students have been trained to work under usual classroom methods. They come to any new scheme of teaching quite unfitted by their previous schooling to avail themselves of more than a few of the advantages which such teaching may offer them. As they become accustomed to the new demands made upon them, they may be expected to respond with increasing assurance and with growing benefit to the new type of teaching. But their adaptation to radical changes in method must necessarily be slow; so that at least at the beginning, there can be no sudden shift from old to new.

The concession which must be made to the life-long experience of teachers is still more fundamental than that demanded by the limitations of students. Brought up under traditional methods of teaching and trained formally or by their own habits into an approximation of these same traditional methods, teachers can seldom free themselves sufficiently to meet the full demands of a radically different plan. They find themselves bound down in part to a certain way of thinking about their own place in the classroom, which

makes it difficult for them, in the case of the suggested procedure, to surrender a traditionally autocratic position for one more appropriate to group learning. They find themselves bound down also to a certain way of thinking about the subject matter which they teach. It is particularly hard for many teachers, apparently, to envisage the essential distinction between subject matter which lends itself to group learning and subject matter which is appropriate to individual learning. Even when the distinction itself is clear, teachers frequently encounter a further difficulty—perhaps, to tell the truth, an insurmountable one with certain types of subject matter: they do not see how to make group learning lead into individual learning, or how to relate students' individual learning to problems of value to the group as a whole. The experience of numerous skillful teachers in various fields of subject matter makes it seem probable that these difficulties are by no means insuperable ones, even though they loom large in the eyes of teachers who attempt an abrupt change in their methods. Hence, like the concession which must be made to the limitations of students, the concession which each teacher must make to his own inability to change himself may be expected to grow less as his experience with the proposed plan of teaching develops. Yet it obviously represents at the outset a major restriction upon the adoption of the suggested methods.

In spite of these obstacles to its complete adoption, however, the proposed plan is by no means devoid of practical value. To the extent to which it can be put into even piecemeal effect, it is likely to bring about an improvement in the quality of classroom teaching. And parts of it can be put into immediate and important effect. Though the average teacher cannot change his hours of teaching or the general allotment of his students' time, he can make various modifications both in what he demands of his students and in the procedure he adopts for himself.

He can, for example, devote his class-meetings to discussion with his students—not lectures to his students—of problems which perplex or trouble or interest his students. He can introduce, for this purpose, problems which admit of profitable group discussion—problems which are unsettled as well as unsettling from the students' point of view. He can select these problems, and guide his students' discussion of them, in such a way as to promise not merely broader understanding of important subject matter, but an increasingly greater ability to deal with problems of various sorts.

He can reduce to writing and make available in printed form the type of information which forms the basis for traditional class lectures. By so doing he may increase the economy and effective-

ness of his students' approach to their individual study, and may at the same time secure added class-periods for profitable group discussion.

He can recognize his laboratory periods, and if necessary certain of his class-periods, as periods for individual learning, and can encourage his students to use them accordingly. Thus he can keep his more formal class-meetings intact for the purpose which they alone can serve—the guidance of group learning.

Through group discussions of what is to be done and how it is to be done, he can pave the way for his students' attack upon each new unit of study or laboratory work which involves new materials or new methods.

He can so organize his teaching that each assignment of laboratory work and outside study is based upon problems related to those being treated in current class discussions, and he can encourage his students to draw upon each phase of their work for its contribution to the other phases.

He can present each part of his course—those parts which involve largely individual study, as well as those parts organized in terms of problems for group discussion—in such manner that his students will see its significance and its value.

He can do all these things at least. If he is sufficiently skillful and his students are able and the conditions of his work are sufficiently flexible, he may find it possible to do more than this. But even if these things and nothing further represent the extent of his accomplishment, he will have established for himself a plan of procedure which goes far beyond traditional method. With a plan of this sort as the basis of his teaching, it seems safe to predict that he need have little fear of competition from mechanical systems or devices, nor of his own ability to justify his job.

CAN INDUSTRIAL ENGINEERING BE TAUGHT?*

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As I understand it, I am here today to justify Industrial Engineering. This is in answer to the Wickenden Report, which discouraged the teaching of industrial engineering subjects and advocated teaching certain subjects in the field of economics and business administration, offering this as an elective to engineering students. I am not going to attempt to do this. In the first place, ever since I read the article, "The Engineer and the Intellectual Life," by Palmer Ricketts, I cannot forget his opening remarks. He said: "Not long ago it was suggested that I write an article on engineering education, but I do not feel competent to do so. I have had only 54 years of experience in this branch of science, and feel that I should leave advice on this subject to those more experienced, and perhaps more dogmatic." So what chance has a mere youngster like myself to pass on a subject of such weight. Also, as this is a meeting of the Society for the Promotion of Engineering Education, I assume that you are all teachers of industrial engineering, or industrial engineers, or possibly even both. In addition this is a sectional meeting devoted to the subject of industrial engineering. For these reasons it seems futile for me to try to tell you why I think the man trained in industrial engineering is better suited for executive and managerial positions than the graduate of the school of commerce. This controversy was very well answered some years ago at a meeting of the Taylor Society in a session devoted to consideration of this problem by the teachers of management. Therefore, I am going to bear heavily on the presentation of the general aims of industrial engineering curricula, and on the needs for men trained in this line by industry.

I shall first give you some results of the questionnaire sent out by Hugo Diemer, who by the way should be giving this talk this morning. Colonel Diemer is chairman of the committee on education of the Society of Industrial Engineers. The results of the survey made by his committee will not be made public until the October meeting of the Society of Industrial Engineers in Washington, but I can give you a few of the outstanding results now by going through it hurriedly. The institutions reporting a distinct

* Presented at the Conference on Industrial Engineering at the annual meeting of the S. P. E. E. in Montreal, June 26–28, 1930.

curriculum, and granting a distinct degree in industrial engineering or industrial management, are 17 in number, one giving a degree of Industrial Engineer, 9 the degree of Bachelor of Science in Industrial Engineering, 3 the degree of Bachelor of Science in Industrial Management, 1 the degree of Bachelor of Science in Administrative Engineering, 1 the degree of Commercial Engineer, 1 the degree of Bachelor of Science in Management, and 1 Bachelor of Science in Industrial Shop Administration. The institutions reporting a distinct curriculum in industrial engineering, or industrial management, but not granting a distinct degree, are 10 in number. These degrees are given as Bachelor of Science in Mechanical Engineering, Bachelor of Business Administration, Bachelor of Science in Engineering, and Bachelor of Science in Engineering Administration, so that the total number of institutions reporting distinct curricula in industrial engineering or industrial management were 27. The institutions offering organized sequences of studies in industrial engineering, or industrial management, these sequences or groups acting as functional or service departments only, and not offering a separate curriculum, were five in number altogether. Seventeen institutions reported that they have no organized sequence of studies in industrial engineering or industrial management, and under this classification the number of options available to engineering students in economics or business administration ran all the way from 1 to 33. When asked the question, "Would you recommend an organized sequence in industrial engineering or industrial management?," six had no comments, four said "Yes," three "No," and one doubtful.

In speaking of industrial engineering, industrial management, and business administration, we come, of course, to the question of definition. So many have been given that I am not going to attempt to formulate one here. I should, however, like to read the definition of Industrial Engineering which was sent in on one of the replies to the questionnaire. The catalog of Lehigh University defines industrial engineering as follows: "Industrial Engineering has to do with the organization, operation and management of manufacturing plants, public utilities and operating holding and managing companies. Broadly considered, it covers the engineering aspects of plant location, plant layout, routing, production control, maintenance, stores and inspection, the economic aspects of employment, employee training, promotion, wage payment, bonus, safety and welfare, insurance and old-age pension and commercial aspects of purchasing marketing, credits, accounting and finance." New branches of management or engineering are opening every day. No doubt you have heard the latest, the so-called "intestinal" management.

It has been found that three-quarters of the graduates of engineering schools eventually occupy administrative positions, and yet in Mr. Wickenden's own report he states that less than 10 per cent. of the production executives are college trained men. Bradstreet reports that of the business failures last year, 80 per cent. were due to incompetence in one form or another, and it is known that less than 10 per cent. of industrial firms have real knowledge of cost. What do all these figures mean? What do they prove? I feel that they show a real need for the trained industrial engineer in industry, and despite the business depression you will all probably concur with me in that your graduating class in industrial engineering has had no difficulty in securing positions.

Recognition of the industrial engineer is slow in coming. He will have to overcome the same inertia that was encountered several generations ago, when the mechanical engineer tried to demonstrate that there was another kind of engineering beside military and civil. When the Kemmerer Finance Commission was organized to go to Poland in 1926, at that time there was no thought of including an engineer. Despite the great opposition, however, Wallace Clark, the outstanding industrial engineer, was selected, and if you doubt for one moment the value of his work on that commission, read the report. His work was so well appreciated that he was called back the following year, and now spends most of his time abroad, and has offices in Warsaw, Paris and Prague. He has been working in paper mills, pulp plants, automotive and alarm factories, steel and brass mills, car shops, and numerous other enterprises. I could go on at length about him and his work, but can only here say that Wallace Clark is doing an excellent job of industrial engineering abroad, and they are coming to appreciate the value of industrial engineering through his efforts.

Let us consider some of the things that have been done by industrial engineers and management engineers in industry, and some of the things that will have to be done. First of all, there has been a pronounced tendency toward a better understanding of time study. The time study sessions of the Society of Industrial Engineers have attracted record attendance. The committee on time study has done a fine job, and expects to have a book out before long. The Taylor Society meetings in Detroit in 1928 were devoted entirely to this subject. The A.S.M.E. time study conference, at their annual meeting a few years ago, attracted a large crowd, and this year the annual meeting of the Taylor Society had on its program an excellent paper by King Hathaway, in which he covered the subject briefly, as he said, in a four-hour paper. At the American Management Association meeting in Cleveland the beginning of this month, announcement was made of the forma-

tion of a new division to cover this field, called the Shop Practice Division, headed by the man in charge of time study at Goodrich Rubber Co. It gives me a good deal of pleasure at this time to inform you that the Detroit Society of Time Study Engineers has just been combined with the Society of Industrial Engineers, so that together the resources of the National Society and the intense interest and hard work of the Detroit group may result in placing this phase of industrial engineering where it rightfully belongs. By time study I do not mean what is commonly known as time study, which is merely rate setting. Naturally, some teachers of industrial engineering or industrial management hesitate to teach this subject when it involves merely a mechanical reading of a stop watch, taking the operation as it is. And, unfortunately, in too many of our engineering schools that phase of time study is all that is taught. I think we feel, and a good many plant men feel, that they should not find it necessary to turn to a university graduate for a mere rate setter. Within the past few months time study has taken on an entirely new aspect throughout the country. People are coming to realize that time and motion study is not a laboratory method adaptable only to certain few particular operations. I wish I had more time to tell you some of the things that are being done in applied motion study at the present time. Outstanding is the work that is being done in Detroit. A few years ago they considered micro-motion study absolutely useless as far as they were concerned. It was all right, they said, for Mrs. Gilbreth, and some of her followers, to make laboratory studies where there were a large number of operators affected doing repetitive work. Their work was different, and until fairly recently, you will have to admit, time study was considered out of the question in the automotive industry. But now, led by Cadillac Motor Car Co., the whole automotive industry is sitting up and taking notice. Mr. Ralph Blakelock, of General Electric, spoke in Detroit on applied motion study, and the effect this had upon the men in time study work has been nothing short of marvelous. Real time and motion study work is going forward, micro-motion laboratories have been set up, and if you get a chance to visit Detroit you must look in on this experiment. Set up in the laboratory are various simple operations showing the old and new methods by application of certain fundamental principles of time study. No equipment has been purchased, and very little money spent. Time study men, foremen, superintendents, supervisors, jig, die and fixture designers and builders, have been brought in and instructed in this subject. These men then go back into the plants and apply these principles to their own work. The results have been tremendously far-reaching. Each workman in the plant is applying these principles.

(The speaker then described in detail a few of the studies being made at Cadillac with the aid of diagrams on the board, and explained some of the motions.)

Now these studies are not going to make the Cadillac car cheaper immediately. The simple study made on the license brackets will not reduce the cost of this car. However, the principle that applies entirely throughout the plant, wherein every foreman, every workman, supervisor, machine designer, and tool designer is thinking in terms of motion and methods, will have a far-reaching effect. This work is just being started, and no one can say where it will end. Some few of you have already adopted the motion picture camera in your class-room work for teaching this subject. In my work at the University of Rochester I felt that the teaching of time and motion study was very important. I felt that it gave the engineering graduate a definite foothold in industry. He then could go out and compete on a financial basis with his fraternity brothers who are bond or insurance salesmen, and feel that he was earning a fair wage. I know of no other work anywhere which will give a man as much insight into human relations, give him as many opportunities to study methods and processes, and definitely decide where we wants to go in industry. I emphasized this teaching, fitting the graduates of the course for good positions as time study men. Very few of them expect to remain time study men, and I am sure that none of them will ever regret this training. I hope that all of you will find it to your advantage to look into this matter, and I hope Professor Porter will, a little later, be able to tell you some of the things that he has been doing with this work at New York University.

Then, in the sales field there is an increasing tendency toward the use of facts as the basis for policies and methods. This is largely due to increased buying intelligence on the part of the public. High-pressure methods and empty oratory are passing out. The conventions of sales managers, and of various trade associations, indicate an increase in the scientific selection and training of salesmen. In market surveys and analyses, and the tie-up of sales management with production, we have the scientific method of approach finding application. No longer is the map taken out and blocked off in rough approximations, and divided into sales territories. No longer are equal sales efforts applied to all fields. No longer is a product handled in the same manner and by the same men. These analyses and surveys enable business to sell as efficiently as it produces. Bankers are beginning to rely more and more on the industrial engineer and his advice. Condition of an industrial establishment, and the granting of unsecured credit, is now submitted to the industrial engineer for his counsel. The ac-

curate facts and figures that are used as a basis for the granting of credit consist of the balance sheet, indicating the present financial status, the profit and loss statement, indicating past performance, and the budget to control future performance. In the old days if a concern wanted to borrow money the ratio of assets to liabilities was investigated. If this was 2 to 1 it was considered satisfactory and the loan was made. If not, they could try all they wished, but in most cases they would not receive the loan. Now the bank has an industrial engineer who goes into the plant and makes a survey more thorough than that made by the average consulting engineering firm. He then passes on the plant's justification for the loan.

The importance of budgeting has been demonstrated recently. The comptroller of one concern has been described by C. E. Knoeppel as one of the men deserving his title of supercomptroller. This man makes up his budgets starting the first of September for the following year. Last year, after the budget was well under way and the crash came, the executives thought perhaps they had better retrench a bit. The comptroller, however, said "No, we will advertise where we have not been advertising before, and advertise more extensively where we have been advertising." As a result of this, you have seen this company's advertisement in two-page spreads and in new media ever since that time. In a business involving a tremendous number of items in tremendous varieties and large quantities, they were, at the end of 1929, within 2 per cent. of their budgeted figure. So far in 1930 there was no curtailment or reduction in the original plan. They are within one-half per cent. of their estimated figure. This concern issues a monthly profit and loss statement twelve months in advance. These new methods of cost control I believe will be the answer to the success or failure of business in times such as we have had in the past few months.

Proper cost analysis has for its basis predetermination and forecasting. You are no doubt familiar with some of the cost control charts used for controlling fluctuating production costs. These costs range all the way from very simple charts, showing cost per mile of operation of your automobile, to very complicated boiler plant operation costs. (The speaker then described and illustrated the hyperbolic cross-section paper, and showed how this could be applied to solution of cost problems.)

Likewise, the method of scientific solution can be applied to the question of inventory control. No longer does the subject of hand-to-mouth buying, and the question of proper inventory, offer the problem it once did. Professor Raymond, of the Massachusetts Institute of Technology, and Professor Davis, of General Motors

Institute, have developed a very satisfactory formula for the solution of these problems. (The author then discussed and showed by illustrations on the board economic lot size and economic minimum purchasing quantity formulæ.)

Lastly, we come to the question of profit control. To my mind, this is by far the most important problem confronting business at the present time, and should be without question given in detail to the industrial engineering student as part of his equipment before graduation. (The speaker then described in detail the profitgraph, drawing this on the board, and explaining the various points and illustrating as he went along.) The General Motors and other figures well illustrate the value of profit control. Dean Kimball, in "Modern Industry and Management," in the book "Toward Civilization," says, "Even more important than the basic principles, specialized labor and the extended use of labor-saving and time-saving apparatus, have been the influence of scientific and engineering methods of thought upon all ideas of management and business. As the background of industry has become increasingly more scientific, the technically trained man has assumed a leading part in industrial management. If the present trends continue there will be little place in the field of management for those unacquainted with engineering technology. These technically trained men have naturally brought their accurate methods of thought to bear on management problems. The old methods of management, which, unfortunately, still prevail in many places, are almost wholly empirical and based upon personal judgment. The engineering methods consist of finding out first what the facts of the problem may be as the basis for the use of judgment. The most profound effect of engineering thought upon managerial efforts sprang from the ability of the engineer to predict with certainty the performance of his product. He quite naturally has tried to apply analytical methods to the prediction of the time and sequence of industrial operations, and to predict in advance how, where and when the productive operations in which he is interested should be performed. To sum up then, let me say, controlled management means the kind of management in which all actions are based on judgments guided by facts which have been intelligently interpreted and simply presented in the same way that the ocean vessel is piloted by management who is continually making soundings, observations, calculations and charting its facts, after which decisions are made with reference to the actions to be taken."

Now, before I close I want to emphasize that I am not saying that the slide rule and the chart are going to take the place of brains. Nothing is further from my mind. No matter how well a man is trained in the technique of operation, a few of which I

have mentioned briefly here, he must be able to apply these properly, he must know when to use this one, and when to use that one. However, I do feel that the trained engineer, with his engineering method of approach to every problem, and his scientific solution, is needed more by American business today than ever before. We are coming to the point where we are beginning to question a man's right to set up in business. In the past too many people utterly unqualified to operate a business have been permitted to do so. The tremendous number of failures attest to this. Good judgment and common sense, together with experience, backed with an absolute knowledge of facts, are essential. It is up to us to give our engineering graduates these tools.

NEW MEMBERS

ADAMS, ARTHUR S., Associate Professor of Mechanics, Colorado School of Mines, Golden, Colo. R. W. Morton, R. A. Baxter.

BALL, THEODORE R., Associate Professor of Chemistry, Washington University, St. Louis, Mo. A. S. Langsdorf, E. O. Sweetser.

BARNARD, NILAS H., Professor of Mechanical Drawing, Tennessee Polytechnic Institute, Cookeville, Tenn. E. G. Young, E. C. Schmidt.

CHERRY, FLOYD H., Associate Professor of Electrical Engineering, University of California, Berkeley, Calif. H. B. Langille, F. L. Bishop.

CLOKE, PHILIP R., Evaluation Engineer, Day and Zimmerman, 3227 Spring Garden St., Philadelphia, Pa. Paul Cloke, R. L. Sackett.

FORRESTER, GLENN S., Personnel Division, E. I. duPont de Nemours Co., Wilmington, Del. R. I. Rees, O. W. Eshbach.

GOVIER, CHARLES E., Professor of Electrical Engineering, Pennsylvania State College, State College, Pa. C. L. Kinsloe, L. A. Doggett.

GRANT, ROBERT J., Assistant Professor of General Metal and Auto Mechanics, State Teachers College, Oshkosh, Wis. Frank W. Walsh, F. G. Higbie.

HEFFNER, ROY J., Educational Director, Bell Telephone Laboratories, 463 West St., New York City. G. B. Thomas, John Mills.

JAMISON, WALTER W., Head, English Dept., Mass. School of Art; Instructor in English, Massachusetts Institute of Technology, Cambridge, Mass. F. G. Willson, E. D. Kingman.

LARKINS, JAMES T., Assistant Professor of Engineering Drawing, Pennsylvania State College, State College, Pa. A. L. Tobias, A. S. Jones.

MATLOCK, JOSEPH R., Instructor in Civil Engineering, Oklahoma University, Oklahoma City, Okla. J. F. Brookes, J. H. Felgar, N. E. Wolfard.

MCGIVERN, JAMES G., Instructor in Drawing, Northeastern University, Boston, Mass. L. F. Cleveland, E. F. Tozer.

MEIKLE, G. STANLEY, Director, Research Relations with Industry, Purdue University, Lafayette, Ind. A. A. Potter, W. A. Knapp.

MIDDLEMISS, ROSS R., Assistant Professor of Mathematics, Washington University, St. Louis, Mo. A. S. Langsdorf, F. L. Bishop.

MURAT, SALIH, Professor of Physics, Robert College, Constantinople, Turkey. L. A. Scipio, Ed. S. Sheiry.

ROBERTSON, BURTIS L., Assistant Professor of Electrical Engineering, Pennsylvania State College, State College, Pa. R. L. Sackett, L. A. Doggett.

SCHELVANOFF, SERGEI A., Member, Technical Staff, Bell Telephone Laboratories, 463 West St., New York City. T. C. Fry, John Mills.

SIROKY, EDMOND, Associate Professor of Applied Mathematics, Washington University, St. Louis, Mo. A. S. Langsdorf, E. L. Ohle.

TEBO, FRANK A., Instructor in Engineering Drawing, Pennsylvania State College, State College, Pa. A. L. Tobias, A. S. Jones.

THAYER, HORACE R., Assistant Professor of Engineering Drawing, Pennsylvania State College, State College, Pa. A. S. Jones.

TUBINI, BERNARD A., Professor of Electrical Engineering, Robert College, Constantinople, Turkey. L. A. Scipio, E. S. Sheiry.

TYMSTRA, SYBREN R., Instructor in General Engineering, University of Washington, Seattle, Wash. F. M. Warner, E. R. Wilcox.

WILSEY, EDWARD F., Professor of Physics, Robert College, Constantinople, Turkey. L. A. Scipio, Ed. S. Sheiry.

THE T-SQUARE PAGE

FREDERIC G. HIGBEE, *Editor*

OBJECTIVE STANDARDS FOR GRADING LETTERING DONE BY ENGINEERING STUDENTS

During 1928, Dr. Clair V. Mann, Chairman of the Research Committee of the Engineering Drawing Division, undertook a study of freehand lettering done in engineering colleges of this country. A brief report of the study was made in the Journal of Engineering Education, June, 1929, pages 979 to 992.

Fifty samples of student lettering on standard cards were collected from each of fifty schools. The cards indicated exceedingly wide differences in:

(1) Importance placed upon teaching of lettering. Some schools of highest standard regarded lettering as so unimportant that none was executed in ink. One school returned lettering executed by a senior student which included words *written in ordinary script* of exceedingly poor quality. This card had been graded 75 per cent.

(2) Character of letter forms taught. About half of the schools follow closely "Reinhardt" ("Engineering News") style and standards of lettering. The remainder have indefinite standards, and certain schools taught letter forms which, with "Reinhardt" standards as a basis, would be considerably distorted.

(3) Standards of grading. The staff of each school graded a single card of lettering provided. Eighty-nine instructors graded the card, results ranging from 75 per cent. to 95 per cent.—average, 89.28 per cent. The same card was graded 88.8 per cent by fifty institutions or staffs involved. 89 per cent. would appear to satisfy both institutions and instructors. Standards of institutions which assigned a grade of 75 per cent. to the card were far from average.

Several definitely measurable characteristics of lettering have been selected which can be used in objective grading of lettering, as:

(1) Consistency of style.

(2) Size. (Uniformity in the size of the letter forms; ratio of height of lower case to upper case letters; intervals between horizontal guide lines.)

(3) Slope. (Adherence to specified slope, 2:5.)

(4) Letter shapes.

(5) Character of stroke. Using the same pen, three different types of strokes are made by students: (*a*) the light uniform stroke; (*b*) the heavy uniform stroke (made by bearing down more heavily on the pen); (*c*) the non-uniform stroke, varying throughout each letter from light to heavy stroke.

(6) Spacing. (Letters within words, words in sentences, sentences on page.)

(7) Letter forms, in themselves correct, not uniformly placed on horizontal guide lines.

DIVISION OF CO-OPERATIVE ENGINEERING EDUCATION

The American industries have expanded at an unprecedented rate, which has produced an urgent demand for executives and supervisors. These leaders are called upon to make rapid analysis of a mass of information, come to a definite conclusion, and immediately set in motion the machinery to produce the desired result. They must be men of alert mentality with confidence in their conclusions and with courage to act upon them. The very nature of the instruction and training in engineering colleges promotes just this kind of mental activity—accurate analysis, definite conclusions and immediate action. But the training of an engineer by the usual educational method confines this process almost entirely to materials while an executive must be trained to apply these methods to human beings.

The Co-operative plan affords the student a chance to try these engineering principles upon situations dealing with human beings. His contact with workmen and foremen early brings to his attention the fact that the good executive must not only be proficient in applying the principles of engineering to all sorts of situations but he must also have a personality which demands respect and loyalty. The student sees the need of developing his own personality as well as his mental powers. If he shows that he has more than the ordinary amount of supervisory talent he is given greater and greater responsibility with the result that at the end of his course he has secured a training not only in the solution of engineering problems dealing with materials, but also with the more difficult problems which deal with those more awkward variables, human beings.

By the Co-operative plan, therefore, it is possible early to discover those students who possess native supervisory ability and to give them some training as executives. This training is elementary, to be sure, but it is none the less effective

W. H. Timbie.

THE LAMME MEDAL FOR ACHIEVEMENT IN ENGINEERING EDUCATION

One of the outstanding results of the recent study of Engineering Education, under the direction of Dr. Wickenden, is a realization of the fundamental importance of good teaching. Buildings, equipment, curricula and heredity count. They, however, are secondary considerations in the promotion of Engineering Education to the enthusiasm, creative interest, ambition and self starting initiative which can be generated in the otherwise average student, by a good teacher.

Realizing the importance of good teaching, the late Benjamin G. Lamme, through his will, has made it possible for the Society for the Promotion of Engineering Education, by the award of a medal, to recognize each year some outstanding accomplishment in technical teaching or some significant advancement of the art of technical training.

George Fillmore Swain of Harvard University, Irving Porter Church of Cornell University, and Charles Felton Scott of Yale University, have been so recognized by the Society.

The members of the Committee on the Lamme Award wish to express their appreciation to the members of the Society for the helpful suggestions which they have made and for the many expressions of approval.

No formal blank requesting your suggestions of those qualified for the Lamme Award will be sent out this year. The Committee, however, would like to have your further cooperation. An informal note suggesting the name of the technical teacher whom you would choose for the 1931 Award together with your reasons for the choice will be appreciated. Please address the Committee in care of Miss Nell McKenry, Assistant Secretary, Society for the Promotion of Engineering Education, University of Pittsburgh, Pittsburgh, Pennsylvania.

COLLEGE NOTES

Antioch College.—In Dean Ayres' interesting article on schools of engineering employing the co-operative plan, which appeared in the November number of the *Journal of Engineering Education,* Antioch was not mentioned. I am giving the Antioch data that correspond with that presented in the November number:

1930	*1925*
Years required—6.	Years required—6.
Co-op. work begins—1st year.	Co-op. work begins—1st year.
Length of alternating periods—5 weeks or 10 weeks.	Length of alternating periods—5 weeks or 10 weeks.
Total co-op. time—151 weeks, maximum.	Total co-op. time—151 weeks, maximum.
Total school time—120 weeks.	Total school time—120 weeks.
Ratio co-op. school weeks—1.26.	Ratio co-op. school weeks—1.26.
Total co-op. enrollment—566.	Total co-op. enrollment—569.

The engineering department was established in 1922.

The Clemson Agricultural College.—Appointments and promotions in the Engineering faculty in the year 1929–30 include the following: S. R. Rhodes, Professor of Electrical Engineering, promoted to head of the department of Electrical Engineering; D. D. Curtis, formerly Assistant Professor of Mechanics and Hydraulics at the University of Iowa, Professor of Mechanics in charge of Mechanics and Strength of Materials; D. H. Shenk, formerly Instructor in Mechanical Engineering at Purdue University, Associate Professor of Mechanical Engineering.

Appointments to the faculty for the current year include F. T. Tingley, formerly Instructor in Electrical Engineering at the University of Illinois, Professor of Electrical Engineering; C. M. Asbill, Jr., formerly with the Westinghouse Company, Assistant Professor of Electrical Engineering; C. P. Philpot, formerly Instructor in Industrial Arts at Georgia Military College, Instructor in Mechanical and Electrical Engineering; P. M. Pafford, recently graduated from Georgia Institute of Technology, Instructor in Mechanical Engineering Laboratory.

J. H. Sams, Jr., Instructor in Mechanical and Electrical Engineering, is on leave of absence for the year 1930–31, doing graduate work in Mechanical Engineering at the University of Michigan.

In the Electrical Department, old equipment has been replaced by modern machines until up-to-date apparatus is available for

instruction in all major lines. Special attention has been given to the development of a standardizing laboratory, and a radio laboratory. A good deal has been done along the line of automatic control apparatus, and a start has been made on a high tension laboratory.

In the Mechanical Department numerous additions to equipment have been made. Noteworthy among these is a refrigerating plant unusual in that it has means of weighing ammonia used. An internally fired boiler is available for test work and for an auxiliary steam supply. In hydraulic work instruction in the use of various measuring devices is made convenient by the tandem placing in a line of a venturi meter, an orifice meter, a weir box with four types of weirs in series, a Bailey weir meter of recording and integrating type, and a large weighing tank.

In the Engineering Shops, the usual work is supplemented by good equipment for welding and for heat treatment.

Recently the Civil Engineering Summer Surveying course has been aided by the donation of 16 acres of land in the lower part of the State, for the construction of a permanent camp. The camp is located in a region that is little cultivated and sparsely timbered so that highway or railway practice location survey lines of several miles length may easily be run. Located on a paved highway, overlooking a small lake with good bathing facilities, the camp is ideally situated. The citizens of Batesburg, who were the donors, named the site "Camp Clarke" in honor of Professor E. L. Clarke, head of the Department of Civil Engineering, who has had active charge of the surveying courses.

In instituting a summer camp for field practice in surveying, Clemson College takes the lead of Southern engineering colleges.

Enrollment in Clemson College is limited by the space available in the barracks, and every fall a considerable number of applicants has to be refused admission. By rearrangement and addition of facilities, this year about seven per cent. more students were accepted. The interest in Engineering is shown by the fact that the increase in number of student engineers is twelve per cent.

The **Massachusetts Institute of Technology** has adopted a new index scale of a student's performance. An average rating is computed by assigning the following values to the various grades and weighting by units:

Honor	= 5
Credit	= 4
Pass	= 3
Low pass	= 2
Failure	= 1
Low failure	= 0

A student who falls below 1.40 in his term rating by this scale disqualifies himself and is dropped at once. Consideration will be given to the case of any student, when unusual non-academic causes, such as continued illness, have prevented him from performing his work.

If he falls below 2.00 during the first year, or 2.20 any term thereafter, he puts himself on probational status. He also goes on probation if his cumulative rating after the first year is below 2.15 to 2.50, depending upon the number of terms he has been in residence, unless his current term rating is above 2.20 to 2.70.

If a student goes on probational status for two successive terms, or for three total terms, he disqualifies himself and is required to leave the Institute.

These actions are automatic. In all cases, however, students and staff have a right to present facts to a Committee of Appeal who may waive the rules in exceptional cases.

This scale was adopted to control the quality of training afforded by the Institute:

1. By eliminating immediately the student who completely neglects to take advantage of his educational opportunities as indicated by an unusually low term record.

2. By warning and eliminating eventually the student who previously has been doing satisfactory work but who is now failing through lack of ability or loss of interest.

3. By warning and eliminating eventually a student whose cumulative performance is below a required quality.

4. By providing means for giving further opportunity to the student whose cumulative record is below standard but who is now improving.

Purdue University.—Rapid development of research work at Purdue University in connection with the industrial growth of the state, was emphasized here with the filing of articles of incorporation of the Purdue Research Foundation. The organization of the Foundation, marks another epoch in the influence of the University and gives a new impetus to the extensive research program of scientific research already under way on the campus of Lafayette.

The Foundation is a non-profit organization and has no capital stock. Its prime purpose is to assist in the financing of the research projects and handling of matters pertaining to inventions and patents for the benefit of the state at large, the University and industrial organizations directly concerned.

Calls upon the University by industries of Indiana especially during the last few years, for assistance in solving scientific prob-

lems vital to their growth have increased with the growing economic importance of the state in national affairs. Recognizing the need for more constructive coöperation the board of trustees of the University in 1927 authorized organization of a special department to handle research relations with industry. G. Stanley Meikle, a well known consulting engineer, was chosen director of the newly created department. As a result of this work, direct coöperation between industry and the University has grown rapidly. This has led to the organization of the foundation to assume the legal and financial responsibilities of the rapidly expanding research program.

The board of directors for the Foundation represents the founders, the board of trustees of the University, Purdue alumni, and the national engineering and research councils.

SECTIONS AND BRANCHES

The Middle Atlantic Section of the Society for the Promotion of Engineering Education held its annual winter meeting at Drexel Institute, Philadelphia, on Saturday, December 6th, 1930.

The morning was featured by most interesting inspection trips to the R. C. A.-Victor Corporation at Camden, N. J., and the new terminal and power house of the Pennsylvania Railroad at West Philadelphia. On returning to Drexel Institute the delegates were served a delicious complimentary buffet luncheon by the Home Economics Department of the Institute.

President C. R. Richards called the meeting to order at 2:30 P.M. and introduced Mr. J. Russell Duane, who spoke most interestingly on certain phases of the life of Benjamin Franklin. Dr. H. C. McClenahan, secretary of the Franklin Institute, addressed the meeting on the subject, "The Franklin Memorial Museum of Philadelphia," the construction of which is planned to start within three or four months. Professor W. T. Spivey, in charge of the Drexel Evening School, spoke on "Intermediate Technical Training."

After a brief survey of the laboratories of the Institute, the delegates assembled in the Picture Gallery at 6 P.M. for dinner and a brief business meeting. The nominating committee, composed of E. H. Rockwell, Lafayette; J. W. Barker, Columbia; and O. W. Eshbach, A. T. & T. Co., presented the names of Director S. S. Edmands of Pratt Institute for President, and C. G. Thatcher, Swarthmore, for Secretary and Treasurer, for the ensuing year. These nominees were elected.

It was voted to accept the invitation of Pratt Institute for the 1931 spring meeting. The report of the Committee on Resolutions was as follows:

> Resolved: That the Middle Atlantic Section of the S. P. E. E. assembled for its Fall Meeting at the Drexel Institute, Saturday, 6th December, 1930, desires to express its deep sense of appreciation to the Faculty and Trustees of the Institute for their generous hospitality, and for the very interesting program arranged for our entertainment.
>
> We also wish to express our thanks to the Pennsylvania Railroad and to the R. C. A.-Victor Corporation for the courtesies and privilege extended to us on this occasion.
>
> L. P. ALFORD,
> F. H. CONSTANT,
> W. S. AYARS, *Chairman.*

This report was unanimously adopted.

After a short entertainment by Mr. T. A. Daly, who recited a number of poems in dialect, the meeting was adjourned at 8:10 P.M.

CHARLES G. THATCHER,
Secretary.

The **New England Section** of the Society for the Promotion of Engineering Education held its fall meeting on Saturday, November 1st, as the guests of the Thayer School of Civil Engineering at Dartmouth College. The morning session was opened at ten-thirty by Dean Cloke and an address of welcome was delivered by Craven Laycock, Dean of Dartmouth College. This was followed by an address by Professor William R. Gray, Dean of the Tuck School of Administration and Finance, on the "Relation between Dartmouth College and its Graduate Schools." Dean Gray traced the early history of Dartmouth College and the history of the various schools, outlining the general curriculum at Dartmouth and pointing out the conditions under which men were admitted to the Thayer or Tuck Schools at the end of the junior year. The first year of work in the graduate school is counted toward the A.B. degree at Dartmouth College, the advanced graduate degree being given for the second year of work in the graduate school.

At two o'clock Dean Cloke opened the afternoon meeting and introduced Chester L. Dawes, Professor of Electrical Engineering at Harvard Engineering School, who read a paper on "The Graduate Work in New England Schools." The discussion was opened by Dean H. E. Clifford of the Harvard Engineering School, who emphasized particularly the desirability of devoting more time to liberal training before taking up the engineering course, making the regular engineering work more nearly graduate in character. Dean Marsden of the Thayer School amplified the statements of Dean Gray made at the morning session concerning the practice at Dartmouth. Professor Arthur E. Norton of the Harvard Engineering School brought out the desirability of more graduate work particularly in engineering mechanics. Professor H. P. Hammond discussed the desirability of part-time graduate work for men already in engineering practice, stating that this was now being done by Massachusetts Institute of Technology, University of Pittsburgh, Union, and Brooklyn Polytechnic Institute. At Brooklyn some two hundred and fifty men are now registered in such graduate work in evening courses, over two-thirds of them working for an engineering degree. Dean Slobin of the Graduate School of the University of New Hampshire emphasized the desirability of some graduate work being done in all institutions. Professor D. C. Jackson of Massachusetts Institute of Technology discussed various phases of the subject, particularly emphasizing various phases of graduate work on undergraduate instruction. Dean Bacon of

Tufts emphasized the point that research work could be carried on in the field without necessarily giving graduate work for masters' degrees. Discussion was closed by Professor Dawes.

Chairman Cloke appointed a nominating committee made up of Professors Farnham and Hitchcock and a committee on resolutions made up of Professors Jackson and Watson. An invitation to hold the fall meeting in 1931 at Brown University was extended. The meeting was then adjourned by the chairman.

Following dinner at the Hanover Inn, the group went to the Thayer School building for the evening session. Professor Farnham, for the Nominating Committee, presented the names of the retiring officers, Dean Paul Cloke of the University of Maine and James A. Hall, Professor of Mechanical Engineering at Brown University, as nominees for chairman and secretary for the coming year and these were elected. Professor Jackson, for the Resolutions Committee, presented the following resolutions:

Whereas, the New England Section of the Society for the Promotion of Engineering Education has just completed an agreeable and fruitful meeting at Dartmouth College at the invitation of the authorities of the College and of the Thayer School of Civil Engineering, therefore in expression of our appreciation of the courtesies accorded it is

Resolved:

1. That we extend to our host, Dartmouth College, represented by its Thayer School of Civil Engineering, our particular thanks for the numerous courtesies which we have enjoyed;
2. That we further thank the local committee, consisting of Dean Marsden, Professor Lockwood and Professor Garran, for the excellence of the arrangements made for our meetings and for the comfort and convenience of attending delegates;
3. That we salute and thank the local ladies' committee, Mrs. Lockwood, Mrs. Garran and Miss Fletcher, for the gracious entertainment of the ladies accompanying visiting delegates;
4. And that we are particularly grateful for the privilege, as a group, of examining the magnificent college buildings, the college campus and the glorious surroundings of this great college, the reputation of which is dear to all Americans.

A. E. WATSON, *Brown University*,
D. C. JACKSON, *Massachusetts Institute of Technology*, Chairman,
Resolutions Committee.

Professor Hammond announced that two summer schools for engineering teachers would be held this coming summer, one in chemical engineering at Michigan, starting on June 24th, and one in mathematics at the University of Minnesota, starting on August 24th.

The secretary announced a registration of fifty-five men and twelve ladies.

Dean Cloke then introduced W. J. Sweetser, Professor of Mechanical Engineering at the University of Maine, who read an illustrated paper on "Flood Conditions in Vermont and New Hampshire."

The local arrangements were in charge of Dean R. R. Marsden and Professors Garran and Lockwood of the Thayer School, who took excellent care of the delegates. The ladies were entertained during the afternoon and evening by a committee of Dartmouth faculty wives.

In addition to the meetings themselves the entire membership had an exceptionally pleasant time sitting around the lobby and parlors of the Hanover Inn discussing topics of mutual interest.

JAMES A. HALL,
Secretary.

BOOK REVIEW

Principles of Engineering Economy. By EUGENE L. GRANT, Professor of Industrial Engineering, Montana State College. The Ronald Press Company, New York, N. Y. 387 pages, 12 charts, 32 tables. Price, $3.75.

The point of view from which this book is written is that the economic aspects of an engineering decision are governed by as definite a body of principles as are the physical aspects of design. While in no way overlooking the importance of the physical aspects, the author's treatment emphasizes many principles frequently overlooked.

The text is clear and ample cases are presented to illustrate the various problems presented. There is a noticeable lack of mathematical formulas, the author having used examples to clarify each principle set forth. In addition there are some hundred and thirty problems for student use. These problems cover an unusually wide range of type and show great thought in their preparation.

Three distinct parts make up the text; namely,

I. The Arithmetic of Engineering Economy.
II. Fact Finding in Economy Studies.
III. Background for Economy Studies.

Numerous chapters, clearly titled, make up each of these three parts. It would be difficult to list all the outstanding chapters without quoting the entire table of contents. Industrial engineers have long felt the need for just such a book,—both for text and reference use.

An engineer has been aptly defined as "a man who can do with one dollar what any fool can do with two." To live up to this definition, every engineer, in any branch of the profession, should be versed in the fundamentals of engineering economics. In writing this text, Professor Grant has filled a long-felt need.

J. W. H.